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BIOLOGICAL ASPECTS OF AIR POLLUTION:
AN ANNOTATED BIBLIOGRAPHY

Harry Heimann, et al

Public Health Service
Washington, D. C.

April 1950

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BIOLOGICAL ASPECTS of AIR POLLUTION

an Annotated Bibliography

by

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Washington, D. C.

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As a public service, the United Steelworkers of America, CIO, is glad to print this bibliography in the hope that it will help to solve the problem of air pollution in our cities.

PHILIP MURRAY, *president*

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INTRODUCTION

The growing interest in air pollution was given a new urgency by the Donora, Pennsylvania, smog episode, during which 20 persons died in October 1948. When the Public Health Service undertook an investigation of the problem, requests for bibliographic information began to come into the agency from many individuals and groups.

In the course of examining all available literature dealing with the biological aspects of air pollution, it was readily apparent that the existing information was not confined to medical publications but was widely scattered. A few efforts, notably the compilation of the bibliography of smoke and smoke prevention prepared by the Mellon Institute of Pittsburgh in 1913, had been made to collate the published material on the subject. However, in the light of the need for current data, it was obvious that a new and up-to-date compendium of the available literature should be undertaken.

In compiling this annotated bibliography, the authors have made no effort to criticize or edit the material covered. No attempt has been made to present complete texts but, rather, it was the aim to give a general review of the material contained in each article. Omissions of significant data may have occurred; but, if so, they occurred inadvertently.

One of the chief problems in the preparation of this work was the matter of classification, and this phase of the project required especially careful thought. As an aid to the reader in finding the material in the text, the table of contents lists items which are in various sections other than under the main headings. In addition, there are extensive cross-references, and an author index, as well as a table of contents by subject matter, is included.

Although every attempt has been made to include all available publications, it is quite likely that some material has been overlooked. The authors would appreciate having such omissions brought to their attention.

Let us say in conclusion that it is a pleasure indeed to express our sincere thanks to the United Steelworkers of America, CIO, including President Philip Murray, Vice President James G. Thimmes, Secretary-treasurer David J. MacDonald, and Mr. Frank Burke, Health and Safety Director, for their interest and assistance in printing this book.

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PATHOLOGICAL EFFECTS

Respiratory Tract

Upper Portion

1. **Smoke and health.** Anonymous. *Smokeless Air* 10: 23, 1939-40.

The "ear, nose and throat club" of St. Louis, Missouri, claims that smoke is an irritant to the membranes of the respiratory passages, creating a fertile field for secondary infections. The Trudeau Society states: "(1) Smoke is a definite irritant to the upper respiratory tract; (2) smoke produces an irritating cough; (3) it aggravates the cough of existing bronchopulmonary diseases."

2. **The effect of smoke on the lungs.** Ascher, L. Stuttgart, 1905. (Abstr. from Varrier Jones, Dis. of Chest 4: 3, 1938)

"Ascher suggests that the increase of smoke in industrial towns must have some bearing upon the increase in diseases of the upper respiratory tract, because, according to his investigations, acute pulmonary diseases are more frequent in industrial towns than they are in the country."

3. **Does smoke abatement pay.** Carter, J. H. *Heating, Piping Air Conditioning* 18: 80, 1946.

Some plants (such as begonias and civerarias) lose their foliage if allowed to remain in a smoky atmosphere for 24 hours. Exposure over a longer period of time results in browning, drooping, or discoloration of the flowers.

With improvement of the smoky atmosphere in St. Louis, Missouri, otolaryngologists agreed that "there has been a definite reduction in infections of the upper respiratory passages and of the tracheobronchial tree."

The smoke used to cause serious and permanent damage to the membranes of the nose, sinuses and lungs, rendering these membranes susceptible to secondary infections. There were increases in "colds, sore-throats, sinus infections, influenza, laryngitis, bronchitis, pneumonia, etc." Smoky air aggravated asthma.

4. **The effect of irritant gases upon the rate of ciliary activity.** Cralley, L. V. *J. Indust. Hyg. & Toxicol.* 24: 193, 1942. (Sept.)

The irritant gases used in the study of the effects on ciliary activity were ammonia, hydrogen sulfide, formaldehyde, sulfur dioxide, chlorine, nitrogen dioxide, and hydrogen chloride gas. The

concentration of these gases producing immediate irritation of the throat agrees roughly with the concentration which causes cessation of ciliary activity without recovery after an exposure of 10 minutes. Thus the concentration which produced immediate irritation of the throat offers a comparative index of the deleterious effect of these gases upon ciliary activity when the exposure is for a short period of time.

For the study, tissue was excised before the cilia were subjected to the gases. Susceptibility of the cilia to gases increased with lapse of time after their removal from the experimental animal. Exposure to small amounts of irritant gases for long periods of time may lead to a chronic irritation of the mucosa which would accordingly affect ciliary activity.

5. Relation of a smoke-laden atmosphere to diseases of the nose and throat. Grayson, C. J. *J. A. M. A.* 47: 384, 1906. (Aug.)

Within a few months following the discovery of natural gas in Pittsburgh, there was a decrease in the incidence of disease of the upper air passages.

6. Air pollution and disease. Keohler, J. P. *Heating and Ventilating* 36: 42, 1939. (Aug.)

The author believes it justifiable to hold polluted air responsible for the following:

1. "The inhalation of smoke and gases causes an irritation of the mucous membranes of the nose, throat, and lungs, thereby causing a congestion which interferes with the normal protective secretion of the mucous membrane, and in that way makes the congested part very susceptible to infection."

2. "Irritation from smoke-laden air is responsible not only for respiratory infections, but also for . . . sinus infection."

3. Some air pollutants may possibly sensitize the individual and produce allergic manifestations. "Asthma has a higher incidence in cities than in the country."

4. A smoky atmosphere causes conjunctivitis by its irritants and also causes eyestrain through interference with proper daylight illumination.

5. "One of the greatest, if not the greatest, health hazards of smoke is its interference with the proper distribution of the available ultraviolet rays of the sun." The absence of sufficient light of this kind can lead to rickets. Ultraviolet rays also have a bactericidal effect.

7. Practical procedures and limitations in present day smoke abatement. Meller, H. B. *Am. J. Pub. Health* 29: 645, 1939. (June)

The magnitude of the job of smoke abatement is emphasized, and

practical suggestions are made for its accomplishment. The limitations of present day methods and equipment are discussed.

A report on 100,000 questionnaires titled "Smog and You" used in the Pittsburgh area revealed that during smog 53 percent had nasal obstruction; 62 percent, a sense of rawness or tickling in the throat; and 25 percent had increased coughing, while 22 percent noted increased "sinus trouble," and 9 percent had no complaints.

8. Smoke, dust, and air pollution. Mitchell, D. R. Univ. Illinois Bull. 35: 110, 1938.

"Harmful physiological effects of smoke include all kinds of respiratory diseases such as common colds, hay fever, asthma, influenza, diphtheria, whooping cough, pneumonia, and tuberculosis; skin diseases of various kinds; stomach disorders in certain instances; and rachitic diseases which are the result of obscuring ultraviolet radiation by atmospheric pollution." Economic losses due to coal smoke are discussed. Methods are given for reducing and preventing smoke. Most of the article is confined to the properties, sizes, and uses of bituminous coal and its products of combustion.

9. Smoke, dust, fumes, and their fellow travelers. Sadtler, P. Chem. Eng. News 25: 2827, 1947. (Sept.)

Industry should take the lead in the abatement of noxious odors and fumes. Not only is the immediate area affected, but fumes also descend on surrounding territory in damp weather, often causing colds, respiratory diseases, and headaches. Sulfur dioxide and hydrochloride fumes also destroy vegetation.

10. Rhinitis due to mechanical irritation of nasal mucosa by floating particles. Ter Heege, F. H. Geneesk. tijdschr. v. Nederl.-Indië 80: 2512, 1940. (Oct.) (English Summary).

"Some examples are mentioned of mechanical irritation of the mucous membrane of the nose. It seems that there is a resemblance of the symptoms of this sort of irritation and those of hay fever and vasomotor rhinitis. With mechanical rhinitis one does not find positive skin reactions, though, on the contrary, with allergic rhinitis it may often be found. The symptomatology of mechanical irritation of the mucous membranes of nose (and eyes) is described from the literature and from the author's own observations, and therapeutic measures are mentioned."

Lower Portion (Lung Parenchyma)

11. Death rates and atmosphere impurity. Anonymous. Brit. M. J. 2: 757, 1935. (Oct.)

Statistical evidence is said to show a close relationship between

death rates and atmospheric conditions. "The number of deaths from lung and heart diseases increases in direct proportion to the intensity and duration of fog smoke." As an example, Glasgow is cited with 75 deaths before the fog, 138 during a three-day fog, and 233 in the week following the fog.

12. Death during fog; big increase among elderly. Anonymous. London Times 1949. (Jan. 7)

The dense fog that occurred at the end of November 1948 was unusual both for its duration and its intensity. It also caused a considerable increase in mortality. There was a sharp rise in the number of deaths registered during the week of the fog—an increase of 20 to 30 percent compared with each of the four previous weeks. As might be expected, the cause of such deaths was in the respiratory system group, including especially bronchitis and pneumonia, among the elderly. The death rate from bronchitis quickly returned to the average level, but the deaths from pneumonia among the elderly and among infants were high in the week after the fog.

The dense fog caused a considerable increase in mortality returns, some details of which are given by the General Register Office in the current issue of the medical journal, *The Lancet*.

13. Smoke and health. Alexander, I. H. Cincinnati J. Med. 22: 492, 1942. (Jan.)

It is admitted that the harmful effects on health ascribed to smoke and air pollution are based on very few observations. There are few scientific facts to establish cause and effect definitely. For example, whereas a rural adult demonstrates small hilar shadows, the urban adult demonstrates increased hilar shadows. Though both are considered "normal," the prognosis in case of tuberculosis is better for the urban dweller. Apparently this is result of fibrosis and lymph blockage.

The correlation between air pollution and pneumonia deaths is discussed at length with tables covering several large cities. It has been established so definitely that predictions of an upturn in incidence of pneumonia deaths can be made for a smog lasting two days or more.

Mention is made of the importance of sunshine to health as well as of the greater loss due to smog during the winter, when days are short, sun is low, and there is more cloudy weather. Air pollution thus intensifies the reduction of sunshine caused by natural conditions during the winter months. Resistance to cold and other illness is reduced, thereby creating a health menace.

14. Coal smoke abatement in England. Ascher, L. J. Roy. Sanit. Inst. 28: 88, 1907. (March)

The author deals mainly with mortality from pulmonary diseases other than tuberculosis. He concludes from his observations that smoke tends to produce acute pulmonary disease and that it hastens the course of tuberculosis. Tuberculosis-infected rabbits which inhaled coal smoke died in an average of 53 days. Those infected with tuberculosis but not exposed to the smoke died in 90 days.

For the City of Manchester there was a reduction in the number of foggy days from 36.8 for the years 1896-1900, to 23.4 for 1901-1905. There was observed a corresponding decrease in mortality from acute pulmonary disease, especially in children, under one year. Statistics for urban and rural districts are given for the period 1902-1904, showing that mortality from acute respiratory disease is higher in cities than rural areas. Smoke is, however, one factor in causing acute pulmonary diseases. Other influences are climate, living conditions, and the presence of harmful organisms. There is a higher death rate from respiratory disease for industrial workers in smoky atmospheres than for rural agricultural laborers. It is 32.6-65.6 per 1000 living in industrial areas and 18.6 per 1000 for those living in agricultural areas.

15. Smoke nuisance in large towns. Ascher, L. Eng. News 58: 434, 1907.

With special reference to tuberculosis, the harmful effects of smoke and soot on the health of individuals are considered. The increase in mortality due to acute pulmonary disease was greater in industrial than in agricultural districts. In the course of 25 years, this increase amounted to 100 percent of infants, and in these districts the increase was most pronounced in those areas having a greater production of smoke.

Tuberculosis spreads more rapidly in smoky districts. Studies with rabbits substantiate the conclusions derived from statistics that soot and smoke cause a predisposition of acute pulmonary disease and a more rapid course in tuberculosis. These animal studies compared the course of tuberculosis in control animals and those exposed to the inhalation of smoke or soot.

16. Smoke and dust. Bordas, F. Ann. d'hyg. 4: 701, 1926.

Most of the article is concerned with the physical properties of smoke and dust. One section is devoted to the effect of smoke on the health of the public.

The polluted atmosphere is considered an important contributory cause to the high death rate from respiratory disease in Manchester, England. Every inhabitant living in the center of the city dies ten years younger than the general average, chiefly because of the polluted atmosphere. The irritant effect increases susceptibility to

tuberculosis. Statistics are given to show the high rate of all deaths and deaths from respiratory disease in particular, in congested industrial areas where smoke pollution is greatest.

17. Atmospheric pollution and health. Clark, R. V. M. Officer 38: 93, 1927. (Aug.)

The City of Manchester is divided into a central and an outlying section with equal populations for the purpose of comparing mortality rates of various diseases. In 1926 only 55 percent of the light received in an area 6 miles south of the city was found in Manchester proper. This reduction is attributed to atmospheric pollution.

18. The effect of the soot in smoke on vegetation. Clevenger, J. F. Mellon Instit. Smoke Investig. Buⁿ. No. 7, 1913.

This paper describes the results of a study of the effect of the soot in smoke on plants. Observations were made in Pittsburgh public parks, along railroads, and at the university. There was also controlled laboratory experimentation.

Results indicated that some plants thrived poorly, while others appeared unaffected. Criteria for undesirable effects were appearance of leaves and annular tree rings and appearance in general. To further justify the assertion that damage was caused by smoke, comparisons were made with plants in non-smoky areas, and, in addition, questionnaires were sent to various plant growers for their observations.

Pines were found to be especially susceptible to damage by soot. The damage is believed to be the result of the action of ash, tar, and gases, rather than carbon particles.

The gases sulfur dioxide and sulfur trioxide are concluded to do considerable damage to vegetation.

19. The air of towns. Cohen, J. B. Annual Report of Board of Regents, Smithsonian Inst. 50: 349, 1895.

Lectures with illustrative experiments show the harmful effects of impurities. As evidence that fuel can be burned smokelessly, a list of firms operating their plants without smoke is presented. In a comparison of health data for urban and rural areas, the life expectancy was found to be reduced in all age groups for urban dwellers.

20. The air we breathe and the sounds we hear. Connolly, J. I. Am. J. Pub. Health 24: 260, 1934. (March)

All aspects of supplying clean air, including types of air conditioning in plants and homes, are discussed. The effects of atmospheric contaminants, such as on health, aviation, buildings, and vegetation, are enumerated. Mention is made of the Meuse Valley disaster and of higher pneumonia rates in urban communities. Recommendations for improvement are given.

21. London's natural history. Chapter 14, The Influence of Smoke. Filter, R. S. R. Collins, London, 1945.

Reflecting the influence of fog, London death rates from respiratory diseases in 1934 rose from 49 the week before the fog to 121 in the last week of the foggy period. Animals also suffered and "suffocated." The fog and smoke have a marked deleterious effect on grass and vegetation.

22. Smoke abatement in relation to public health. Galloway, R. M. J. Inst. Fuel 20: 194, 1947. (Abst. C. A. 41: 7030, 1947) (Nov.)

"There is sufficient silica, tar, and sulfur dioxide in the air of most industrial areas to cause some degree of pulmonary fibrosis, to irritate the respiratory mucous membranes and to predispose to respiratory diseases. There is a rising incidence of cancer of the lungs, the exact cause for which is unknown, although Ralston Patterson blames it on road dust. Sunlight is greatly reduced by smoke, with a reduction in the feeling of well-being. While obvious, the effect of this reduction is difficult to measure. Foggy periods tend to increase the deaths from respiratory disease and to increase the incidence of pneumonia and acute bronchitis in the young and old. Death from respiratory disease appears to be markedly less in towns with relatively clean atmospheres than in highly polluted areas."

23. Necropsy evidences on the relation of smoky atmosphere to pneumonia. Haythorn, S. R. and Meller, H. B. Am. J. Pub. Health 28: 479, 1938. (April)

An analysis is made of 3,000 autopsies following deaths from various diseases in Pittsburgh. Examinations were done to determine the kind and extent of lung change and the amount of visible dust deposits. The autopsies represent a cross section of the population. Correlation of pneumonia deaths with smog showed increased incidence of pneumonia during the following smog. Pneumonia morbidity decreased in economic depressions when industry was at low ebb.

Necropsied lungs were graded microscopically for pigment and fibrosis. All forms of pneumonia were graded as to pneumonic type. Grading ranged from I, representing minimal pigmentation, to V for excessive fibrosis and pigmentation. Grade 0 meant no pigmentation. Correlation was then attempted between the type of pneumonia and pigment grade. Groups 0, I, and II had no occupational basis. Grade III was mixed occupational and nonoccupational. Groups IV and V were almost all related to occupational.

No relation was found between incidence of pneumonia and mild

grades of pigment. In Grades III, IV, and V, there was a definite higher percentage of pneumonia, but the average age for these grades coincided with the age when the pneumonia death rate in less smoky cities is likewise highest. Healing by organization was increased in upper grades. Conclusion: no significance should be attached to pneumonia and pigment grades except increased organizing fibrosis with marked pigmentation of lung.

24. Wartime policy for smoke abatement. Jervis, J. J. M. Officer 63: 142, 1940. (April)

With wartime increase of industrial output there is increased atmospheric pollution, and, in addition, the reduced interest in civic activities tends to minimize the control of atmospheric pollution. Consequently, heavy smogs are appearing which increase the incidence of respiratory disease. Leeds experienced one of the blackest smogs in its history during January 1940, at which time a death rate from respiratory diseases soared to a high level.

It is argued that to allow deterioration in smoke abatement enforcement damages the health as well as wastes fuel.

25. The combat with atmosphere pollution. Jervis, J. J. Chapter 7, Modern Trends in Public Health Arthur Massey, editor, Paul B. Hoeber, Inc. New York, 1949.

This chapter contains a comprehensive coverage of various aspects of atmospheric pollution, including causes, sources, and varieties (liquids, gases, and solids) of pollution, and the source, composition, and effects of smoke. In the description of the effects of smoke, photographs are included of lettuce and cabbage leaves which were grown from the same seed in both non-polluted air and smoke. Health implications are pointed out in the statement that "every medical officer of health of an industrial area knows that a rise in the death rate is to be expected after a smoke fog . . ." Graphs are shown for three towns correlating deaths from respiratory diseases with foggy days, temperature, and with weekly incidence of sunshine. The incidence of deaths was much higher in the town with the least sunshine (Leeds), although the temperature in all three towns was comparable. Measurements of smoke and soot-fall is discussed at length, including methods of reduction and control. Although this report covers atmospheric pollution in Great Britain, a section is devoted to a limited consideration of the same problem in other countries.

26. Papers on the Influence of smoke on health. Klotz, O. and White, W. C. Mellon Inst. Smoke Invest. Bull. No. 9, 7, 1914.

A. The Relation of Atmospheric Smoke and Health: Cohoe,

B. A. 7. In 1911, smoke was considered beneficial rather than harmful, even though some suggested its injurious qualities in pulmonary diseases. Some health officers believed that the acid and carbon particles destroyed lung tissue, were generally detrimental to health, and caused disease. Investigators have noted the higher incidence of death from pulmonary diseases in smoky areas as compared with that in smokeless, rural areas. Inhalation of coal dust leads to chronic bronchitis, followed by emphysema in miners. Carbon monoxide is found in smoke and is poisonous when inhaled in sufficient quantities; carbon dioxide, another constituent of smoke, is produced in almost lethal amounts about some factories. Sulfurous fumes are the most dangerous part of smoke. Arsenic, also found in smoke, lowers man's resistance to disease and infection; nitrogen and chlorine gases play a minor role in the effect of smoke upon health. Fog is productive of much illness, with an increase in deaths during the week following the fog. Fog diminishes sunlight and causes a decrease in ultraviolet rays.

B. Pulmonary Anthracosis—A Community Disease: Klotz, O. 64. The most intense anthracosis appears among coal miners. All city people have some degree of pigment in the lungs. Carbon is very inactive and not detrimental to the person's health. Carbon particles get into the lung lymphatics and appear in definite areas with a characteristic arrangement.

C. The Bacteriology of Soot: Holman, W. L. 104. Soot appears to be bactericidal and is not a favorable nidus for the collection of bacteria. Phenols contained in soot are believed to give soot its bactericidal action. Sunlight, too, is bactericidal, but solid particles in smoke may mechanically block this action.

D. Some Histological Evidences of the Disease Importance of Pulmonary Anthracosis: Haythorn, S. R. 123. The anthracotic process in which carbon particles are deposited in the tissues of organs is described. Anthracosis is inactive in tuberculosis. In severe acute inflammatory conditions, anthracosis blocks the lymphatics and the results are detrimental.

E. The Influence of Smoke on Acute and Chronic Lung Infections: White, W. C. and Shuey, P. 164. As the number of smoky days decrease, there is a general tendency for the chronic lung disease (tuberculosis) death rates to rise and for the acute lung disease death rate to drop.

27. **Atmospheric pollution in Dublin during the year 1939.** Leonard, A. G. G., McVerry, B. P. and Crowley, D. *Sci. Proc. Roy. Dublin Soc.* 22: 257, 1940.

A report on air contaminants, listing the various types, is pre-

sented for the year 1939. Graphs indicate monthly levels of suspended impurities. Other measurements include sulfur dioxide and sunlight. Pollution by suspended matter is compared with deaths from respiratory diseases.

"It is a well-established fact that the death rate from respiratory diseases is higher in cities than in rural areas, and in large cities, such as Manchester, periods of fog are followed by a rise in the death rates from such diseases. City fogs are due to an increase in the amount of suspended matter present in the air."

A graph comparing the intensity of air pollution each week with the weekly total of deaths from respiratory diseases in Dublin shows markedly similar curves. It is concluded that any pronounced rise in pollution during the winter is followed shortly by a rise in the death rate.

"It is to be remembered that high pollution by suspended impurity is accompanied by corresponding high pollution by sulfur dioxide, and also that periods of high pollution by these quantities are always periods of low temperature."

A comparison of death rates of Dublin county and the city are given, showing a marked increase in the city, due allegedly to air pollution.

28: Fog and mortality. Logan, W. P. D. *Lancet* 256: 78, 1949. (Jan.)

The dense fog that enveloped London and much of the country during the closing days of November 1948 established a record, not for density but for duration. Commencing in London on the night of Friday, November 26, it persisted until Wednesday, December 1, thus straddling the forty-seventh and forty-eighth week of the year. A table is given for total weekly deaths from all causes registered in London during from 44 to 51 weeks for the year 1944 through 1948. A second table gives the death from nine selected causes. Deaths from bronchitis are broken down into age groups in a third table. The same is done for pneumonia in Table 4. These last two tables give deaths in age groups for each of the 44 to 51 weeks in the year 1948.

The sharp rise in deaths registered during the week of fog stands out clearly, 20-30 percent more deaths being recorded in that week than in any one of the previous 4 weeks. The effect continued into the 49th and perhaps the 50th week of 1948.

Another table indicates that much of the increased mortality was due to respiratory infection. Registered deaths due to bronchitis and pneumonia more than doubled during the 48th week with some increase from myocardial degeneration and cancer. Other causes were

little, if any, higher than in the previous four weeks.

Tables 3 and 4 reveal no increased mortality from bronchitis or pneumonia under age 45. The increase was numerically greater above 65 but proportionately greater in 45-65 age group. In the next two weeks (49 and 50) the bronchitis death rate returned to normal, but deaths due to pneumonia in the elderly remained high.

Infant mortality due to pneumonia was not increased during the week of fog but went up the following week.

29. Smoke and the public health. Macgregor, A. M. Officer 78: 157, 1947. (Oct.)

"There is evidence that during the past quarter of a century, the production of smoke has lessened, and its ill-effects on health have diminished." The deleterious effects of smoke are worse when fog and frost appear together with the smoke. This increases the mortality of pneumonia and bronchitis during the smog and for weeks thereafter.

"One of the worst examples was a fog of 74 hours' duration, accompanied by frost and influenza, in Glasgow in January 1929, when the death rate rose to the high figure of 50.3 per 1,000 in the third week of the month as compared with 15.3 per 1,000 population for the whole year. In 1928, Manchester had 13 days of fog during February, the death rate rising to 34.4 per 1,000 by the end of the month as compared with the annual rate of 13.2 per 1,000." Leeds experienced the same due to a 6-day fog.

Smog irritates the mucous membrane of the respiratory tract and is "especially felt by elderly people with a tendency to bronchial catarrh." These people are the first to become ill when a smog appears. Of the Glasgow deaths, 49 percent were due to respiratory diseases. Smoke is thought to be responsible for at least part of the higher mortality rates of children under 5 years of age from pneumonia and bronchitis in one of the industrial towns. It is estimated that smoke eliminates 50-80 percent of the sunlight and is thus detrimental to health. A table demonstrates the loss of daylight and ultraviolet radiation in the center of an industrial town as compared with that of the country.

"A recent publication by the Department of Scientific and Industrial Research says that in the towns and cities of the British Isles there are many people whose state of health would be improved by additional sunlight."

30. Urban air pollution and respiratory diseases. Mills, C. A. Am. J. Hyg. 37: 131, 1943. (March)

A study was made of the relationship between air pollution and respiratory disease, with a comparison between Cincinnati and

Pittsburgh. The sootfall and pneumonia rates were found to be much higher in Pittsburgh. In both cities, sootfall and pneumonia rates were higher in the low-lying industrial areas. A similar close relationship was found with tuberculosis. Socioeconomic indexes compared favorably with the results to add another possible causative factor. The increased incidence of pneumonia in men was attributed to greater exposure in view of the insignificance of the sex difference in rural areas. The winter smog is discussed as an important agent in the incidence of pneumonia. The possibility of carcinogenic material in smoke is also mentioned.

Recommendations are made for reducing air pollution: the use of low volatile coal, fly-ash trapping, preliminary coal washing and use of diesel locomotives.

31. Smoke and health. Mills, C. A. Rhode Island M. J. 28: 496, 1945.

There exists a highly significant relationship between atmosphere pollution (sootfall) and respiratory disease death rates in the various districts of Cincinnati and Pittsburgh.

32. Pollution factors in urban atmospheres. Mills, C. A. Cincinnati J. Med. 27: 441, 1946. (July)

The deleterious effect of air pollution on health is emphasized as much more important than the economic damage and the drab and dirty appearance of the industrial city. The various components of smoke are dealt with separately. "Carbon particles in the air have never been shown to be harmful to man in any way." Hydrocarbons form the tarry material on the soot flakes, and it is this tarry carbon which dirties clothing.

"Certain of the condensed tar constituents have been shown to be capable of inducing various types of cancer in susceptible animals and have been suspected of being factors in the rapidly rising lung cancer rate in man." Sulfur gases are an irritating factor of smoke. "These gases when inhaled by man are quickly and completely dissolved in the moist linings of the air passages and exert their irritating effects . . . Carbon monoxide is of little consequence in the city atmosphere generally."

33. Atmospheric sewerage: air pollution problem. Mills, C. A. Heating, Piping Air Conditioning 18: 85, 1946.

The author states there is a highly significant relationship between atmospheric pollution, as determined by sootfall, and respiratory disease death rates in the various districts of Cincinnati and Pittsburgh. Also, the incidence is much higher among males (two to three times), whereas little difference exists between male and female in suburban areas. Respiratory diseases, including

influenzal infections, account for about 70 percent of working time lost by employed persons on account of illness. The smoke problem should be considered on a health basis alone without regard to the other savings which would accrue with smoke elimination.

34. The relationship of smoke to pneumonia and other infections of the respiratory system. Mills, C. A. Cincinnati J. Med. 27: 624, 1946. (Sept.)

Statistics are presented to show that the mortality due to pneumonia and tuberculosis is in direct ratio to the amount of atmospheric pollution. For Cincinnati and Pittsburgh, the incidence was highest in the low-lying parts of the city, where sootfall was also greatest. A close relationship also exists between pneumonia rates and such socioeconomic indexes as rental values, overcrowding, and income. The comparison of male and female rates, however, does not bear this relationship out. A comparable rate would be expected for the same families. Actually, however, the incidence in males in polluted areas is twice that of females, whereas in higher suburban districts, regardless of income group, the ratio is about 1 : 1. It is concluded that the difference lies in that at work the men are more exposed to polluted air.

35. Smoke and Health. Mills, C. A. Canad. Hosp. 23: 47, 1946. (April)

Ascher pointed out, that the pneumonia mortality is 135 percent higher in men of the Ruhr Valley than in Prussian men of similar age groups, with the death rate highest in the industrialized areas of greatest pollution. Pneumonia causes six times more deaths in industrial than in rural populations. It was found that coal smoke quickened tuberculosis deaths in laboratory animals and increased their susceptibility to pneumonia. "The damaging effect on people was greatest in those industrial areas where humidity was high and fogs prevalent."

In surveys made of sootfall and respiratory disease rates in Cincinnati and Pittsburgh, there is a close relationship between high pneumonia death rates and heaviest sootfall. "Although the evidence strongly suggests the presence of carcinogenic air contaminants in the smoky districts, the proof of its relation to human cancer is still not entirely settled."

Because the respiratory hazard is so much greater for men (50-90 percent) of the laboring classes than their wives, atmospheric pollution is pointed out as the responsible factor.

36. Health costs of urban air pollution. Mills, C. A. and Mills-Porter, M. Occup. Med. 5: 614, 1948. (June)

This is an extension of a previous study regarding air pollution

and death rates due to respiratory disease. The earlier study was based on findings at Pittsburgh and Cincinnati. This report covers surveys of Chicago, Detroit, Nashville, Tennessee, and Atlanta, Georgia, as well as a resurvey of Cincinnati. The observations were reported to show a fairly uniform response pattern.

Findings for each city are given in detail showing death rates due to respiratory disease, broken down into sex and race, by census tract, and for sootfall district within the city. Death statistics based on 1940 census figures are given for 1944, 1945, and 1946, and the rates are correlated with sootfall rates within the various districts. No sootfall data were available at Atlanta, Georgia, Birmingham, Alabama, or Nashville, Tennessee; in these cities, as the result of a personal survey, the findings were divided into "clean," "intermediate" and "dirty" districts.

Conclusions include: Death rates for pneumonia, pulmonary tuberculosis and respiratory tract cancer bear a direct and significant relationship to the intensity of pollution in urban atmospheres. Males are affected by the pollution more than females. In Chicago this difference between males and females was 10 : 1 for pneumonia and tuberculosis and 4 : 1 for cancer.

37. The relation of smoke and health. Niven, J. Confer. Proc. Smoke Abatement League of Great Britain 54, 1911. (Nov.)

The first part of this report deals with the laws to control smoke and the progress made in its abatement.

For a measurement of the effect on health, the author uses the death rate for different years although he admits that this is an imperfect criterion. Tables are given for the annual death rate of Manchester for 1838 to 1910. There is a decrease from 35.8 per 1,000 population to 25.24 per 1,000.

A table compares the relative mortality from chest diseases of Manchester with other towns, and a record of sunshine is also given. "It will be seen that the death rates from pulmonary disease follow more closely the social circumstances than the atmospheric conditions of districts."

Fogs do not allow the dispersal of sulfur dioxide. The increased rate of deaths from respiratory disease follows fog. "The increase in mortality from bronchitis, like the increase from phthisis, follows more closely on the fog than does that from pneumonia."

38. Atmospheric pollution. Osborne, H. M. Officer 39: 63, 1928. (Feb.)

The remarkable reduction in enteric diseases is considered a mark of success in efforts at improved sanitation. The continued high

rate of respiratory diseases will continue until the foulness is removed from the atmosphere.

Average mortality figures for bronchitis, pneumonia, and other respiratory diseases from the years 1921 to 1925 are given for various British communities. Areas in which deaths from bronchitis are more than 50 percent greater than that of England and Wales as a whole are indicated. Among the highest were Manchester and Salford, which are noted for their heavy smoke pollution, dampness, rawness, and relative absence of sunshine. Domestic tarry smoke is implicated as the chief offender.

It is the common experience of local doctors to find their bronchitis patients dying off in numbers during prolonged periods of winter fogs. In the author's report of 1923, charts were produced showing a close relation between periods of winter fog and deaths from respiratory disease. There is little doubt that a smoke-polluted atmosphere is responsible for much of the nasal and bronchial catarrh which is prevalent.

An indirect but serious effect of smoke is loss of sunshine. Such loss leads to increased incidence of rickets, anemia and tuberculosis and to interference with normal growth.

The year 1926 saw the lowest general death rate ever recorded at Salford, and the biggest reduction was in deaths due to respiratory diseases. The author correlates this with the prolonged coal strike and the consequent relatively pure atmosphere for that year.

39. Smoke abatement; a symposium. Ritchie, A. W. and Langrishe, J. *Chemistry & Industry* 54: 979, 1935.

Ritchie discusses causes of smoke, measures taken for its reduction and methods of smoke and atmospheric pollution investigation. Langrishe discusses the effects of smoke on health. He reports in part, "Statistical evidence shows a close relationship between death rates and atmospheric conditions, the number of deaths from pulmonary and heart disease increasing in direct proportion to the intensity and duration of smoke-fogs." He also cites Smith, who reported that "in November and December of 1909, Glasgow had three periods of dense smoke-fog. Deaths from respiratory diseases during the week previous totalled 75; during the week comprising the first period they amounted to 138; while in the ensuing week they rose to 233. Over the whole period of bad fogs the death rate from respiratory diseases rose from 2.1 per 1,000 to 13.0 per 1,000, an increase of 11.8 per 1,000; while in seven other towns which were fog-free during the same period it rose from 1.4 to 4.8 per 1,000, an increase of only 3.2. Had the Glasgow death rates from all causes been increased only in the same proportion as in those other towns, the actual number of deaths would have been 1,000 less."

The action of solar radiation is discussed, as are also the effects when sunlight is obstructed. These include loss of visibility, psychological smoke-gloom, and increased incidence of rickets and cachectic states. There is also a brief discussion of the Meuse Valley disaster.

40. Sulphur dioxide poisoning as a cause of asthma. Romanoff, A. J. J. Allergy 10: 166, 1939. (May)

"Cook believed, on clinical grounds, that there may be a certain specificity in the inhalation of sulphur dioxide fumes, principally because this gas initiates attacks in relatively few asthmatic individuals, and in those who were free from asthma attacks for some time. However, there is no immunological proof of the specificity of sulfur dioxide fumes in initiating attacks of bronchial asthma." Those exposed to sulfur dioxide fumes have an inflammatory, destructive lesion in the upper respiratory tract. The mucous membranes are rendered helpless, and the bacteria gain the upper hand. The inhalation of sulfur dioxide is very irritating to the upper respiratory tract. Sulfur dioxide plus moisture of membranes forms sulfurous acid, which is very irritating and in severe cases can produce bronchopneumonia and pulmonary edema. A group of 100 people with chronic exposure to sulfur dioxide had a diminution of taste and smell, an increase in the incidence of pharyngitis and tonsillitis, and an increase in fatigability and dyspnea on exertion. Three cases of asthma in refrigerator repair men are cited in which sulfur dioxide is said to be the cause of the asthma.

41. Effect of inhalation of smoke from common fuels. Schnurer, L. Am. J. Pub. Health 27: 1010, 1937. (Oct.)

Rabbits and rats were exposed to flue gases in such proportion that concentrations of sulfur dioxide and carbon dioxide were below generally toxic levels; not more than a trace of carbon monoxide was allowed, and oxygen was kept at 19 percent. Fuels used were anthracite, coke, and bituminous coal.

Weight gain was lowest with bituminous coal. The bituminous group had the most marked blood changes, leukocytosis, increase in hemoglobin, and increased red blood cells. Deaths occurred from bronchopneumonia, miliary abscesses, and abdominal parasites. At autopsy it was found that pigmentation in the lungs varied from slight, in controls, to massive, in bituminous exposures. Some lungs showed congestion, collapse, and emphysema in discrete areas. Liver and spleen showed phagocytes loaded with black granules which proved not to be carbon. Anthracite-coal-exposed animals showed the least changes evidencing little difference from the controls. In the case of bituminous coal, the animals showed intense pigmen-

tation of the lungs and peribronchial nodes. Carbon was both intra- and extra-cellular. Coke-exposed animals showed changes intermediate between those found in the animals exposed to anthracite and bituminous coal.

Results were comparable for animals killed immediately at the end of the exposure, and 108 days after the exposure except that beginning fibrosis was found in lungs of one animal exposed to bituminous coal fumes. In animals killed after 14 months, evidence indicated that, despite intense pigmentation in the animals exposed to bituminous coal for one year, phagocytosis continued and carbon became concentrated in huge foreign-body giant cells.

42. Further studies on the relation of pneumoconiosis to respiratory diseases in the Pittsburgh district. Schnurer, L. J. *Indust. Hyg. & Toxicol.* 20: 14, 1938. (Jan.)

A series of cases of adults of similar social rank, studied for the relation of dust deposits in the lungs, is reported. The pneumonia case and death rates, and the incidence of pneumonia cases in which "organization" occurred, were found to increase in direct proportion to the degree of pneumoconiosis. A similar increase was found in the incidence of bronchitis and emphysema. The occurrence of active tuberculosis and the tuberculosis death rate were found to be inversely proportional to the degree of pneumoconiosis.

The type of dust present in the Pittsburgh district is made up largely of carbon particles and amorphous ash for soft coal. Very little free silica is present, yet the amount of fibrosis found about pigment-bearing cells was considerable. While there was a relatively large number of cases of primary cancer of the lung, the occurrence was interpreted as having a relation to the age group, since there was a concurrent increase in extra-pulmonary malignancies.

43. How to get a smokeless atmosphere and make it pay. Smith, W. B. *J. State Med.* 34: 422, 1926. (July)

The author states that "smoke affects health directly by its ill-effects on the organs of respiration and indirectly by diminishing the amount of sunshine and cutting out a considerable proportion of the ultraviolet rays." He shows the direct effect of smoke on the death rate of Glasgow and that the rate was due to respiratory diseases. Many cases of rickets and tuberculosis are said to be caused by smoke. There is also a close relationship between pulmonary and cardiac diseases and smogs. "The cause underlying the high mortality in towns, which is known to follow in the wake of a fog, must operate continuously, though in a lesser degree, on the health of an urban community."

Smokeless fuel is discussed at length in the article.

44. Smoke and health. Taylor, J. S. Nat. Smoke Abatement Soc. 1929.

Carbon from coal fires is deposited in the lungs of city dwellers. "The tarry matter and the invisible sulfur acids, which are more dangerous than the carbon, set up an irritation in the mucous lining of the tracheobronchial tree. Chronic catarrh supervenes. The mucous lining becomes rough and thickened; the surrounding tissues lose their elasticity and become leathery in texture. These changes produce symptoms of chronic bronchitis, symptoms resulting from persistent irritation, partial collapse of the lungs and incomplete oxygenation of the blood. To make up for this deficiency certain areas of the lungs undergo compensatory distention. The air vessels are enlarged, but, owing to the change in their lining, they function less. Their walls are atrophied and the fine network of the blood vessels disappears (emphysema). Now the blood is incompletely purified, the heart has to work overtime to rid the blood of its poisonous gases. This, therefore, is the sequence of pathological changes, catarrh, bronchitis, emphysema, heart failure."

It is believed that a major factor contributing to infant mortality is "a smoky and dusty atmosphere."

The incidence of deaths from respiratory disease and the occurrence of foggy days are plotted on a chart.

Rickets and anemia are attributed to a lack of sunshine, due to smoke.

45. Smoke and health. Taylor, J. S. Clean Air 1: 58, 1930.

The impurities in the atmosphere in Manchester amount to 20,000 tons of solid matter, 75,000 gallons of tar, and 250,000 gallons of acids per year.

"The result of breathing air, so badly polluted, on the lungs is chronic irritation of the bronchi, a susceptibility to bacterial infection, deposition of soot, in the lung tissue with resulting catarrh, bronchitis, emphysema and cardiac failure . . .

"After a fog in which atmospheric contaminants are concentrated in the lower layers of the atmosphere there is considerable increase in the death rate from respiratory diseases."

46. Smoke eradication to save the health value of urban sunshine. Tonney, F. O. and DeYoung, C. R. Am. J. Pub. Health 21: 344, 1931. (April)

Studies have been made in several American cities which show a decided loss of the short rays and actinic intensity of the sun most of the year.

Two charts are presented: one on the "relation of total deaths to erythema hours of sunshine per month in Chicago, 1926-7"; the

other on the "relation of deaths from acute respiratory disease to erythema hours of sunshine per month in Chicago, 1926-7."

"The striking feature of these charts is a remarkable correlation between respiratory disease deaths and erythema hours per month; low erythema hours are observed to be followed by high respiratory death rates with a lag of 1 to 2 months, and, conversely, the higher erythema hours per month are followed by correspondingly lower respiratory death rates, after a similar lag."

47. A study of the influence of varying densities of city smoke on the mortality from pneumonia and tuberculosis. White, W. C. and Marcy, C. H. *Fifteenth Internat. Cong. Hyg. and Demog.* Wash. (1912) 3: 1020, 1913.

Statistics are given for 1909-1911 showing the relationship of the tuberculosis and pneumonia death rates with smoke content of the air with particular reference to Pittsburgh. A map of Pittsburgh is shown dividing the city into wards, and the average density of the smoke is shown by various densities of shading. A graph depicts the pneumonia death rate and smoke content of the air by wards. Another plots similar information for tuberculosis death rate. Chart 4 compares the pneumonia death rate and smoke content of 15 cities of the United States. The correlation of death rates from pneumonia and smoke content is striking, with the exception of observations in Chicago, where the smoke content was comparatively low and yet there was a very high pneumonia death rate. In the various cities, smoke content was based on the distance of vision, using standard observation equipment, whereas, in Pittsburgh, carefully devised studies of precipitation of air content of carbon dust served as the criterion.

It was concluded that smoke is a very important factor in the unusual severity of pneumonia, as encountered in Pittsburgh, and that some other factor must operate in those cities where the smoke content is comparatively low and the pneumonia death rate is still high. It was also concluded that no correlation existed between smoke content of the air and the tuberculosis death rate.

48. The influence of smoke on acute and chronic lung infections. White, W. C. and Shuey, P. *Mellon Inst. Smoke Invest. Bull.* No. 9, 164, 1914.

For this study, pneumonia was the criterion for an acute lung infection, and tuberculosis for a chronic lung infection. In addition to smoke, other factors that may contribute to the drawing of any conclusions are discussed. In the various large cities in the United States where the study was undertaken, the number of years that the city had been incorporated and flatness of city contour were

considered. Cities were plotted in decreasing order of smokiness for years 1908-1912 against mortality due to pneumonia and tuberculosis. Pneumonia showed a higher incidence in the smokier cities. On the other hand, mortality to tuberculosis increased as the number of smoky days decreased. No statistics were given to indicate if the difference was significant. There were some exceptions to the above deductions in some cities.

- 49. Chronic lesions of the respiratory tract, initiated by inhalation of irritant gases.** Winternitz, M. C. *J. A. M. A.* 73: 689, 1919. (Aug.)

Most irritant gases cause an inflammatory edema followed by a cellular exudate both in upper air passages and in lung parenchyma. The highest mortality with high concentrations occurs in the acute, edematous stage with a second peak in the pneumonic process. Under particular consideration in this article were the effects of the war gases, mustard, chlorine, and phosgene, which have an initial necrotizing action.

- 49a. The influence of fog on mortality from respiratory diseases.** Russell, W. T. *Lancet* 207: 335, 1924.

This is a report of a study of mortality from respiratory diseases for a 27-year period in two areas in Great Britain. It was found that foggy days associated with low temperature showed the highest mortality from respiratory diseases. No increase in mortality rates from these diseases was found when fog existed with relatively high temperature. (It is to be observed that the term "fog" as used in this report is probably a combination of fog plus air pollutants of an industrial nature.)

Pulmonary Tuberculosis

- 50. Review of various studies and observations from papers by Louis Ascher.** Cohoe, B. A. *Mellon Inst. Smoke Invest. Bull.* No. 9, 19, 1914.

Cohoe considers the work of Ascher as the most comprehensive study of the direct effect of smoke upon the respiratory organs. Ascher has published several monographs dealing with the subject both from the standpoint of vital statistics and animal experimentation.

Ascher uses statistics to show the increase in pulmonary deaths in industrial areas. He also gives statistics indicating the fallacy of the belief that miners are relatively immune to tuberculosis. He reasons that a miner is an invalid at 40 and dies of an acute pulmonary condition. Miners die from acute disease before tuberculosis can take over. Also, mortality to tuberculosis is not low among

laborers working in coal dust and smoke. Coal carriers, chimney sweeps, and soot handlers have a high tuberculosis mortality. Ascher maintains that the low mortality from tuberculosis among coal miners is due to the choice of workmen especially fit for hard work and to the fact that they earn a higher scale of wages and live under good social conditions. Thus Ascher blames smoke particles for the high incidence of acute respiratory conditions and disbelieves any claim of immunity in workers to tuberculosis.

- 51. Some histological evidences of the disease importance of pulmonary anthracosis.** Haythorn, S. R. *J. M. Research* 29: 259, 1913. (Dec.) (Abstr. Mellon Inst. Smoke Invest. Bull. No. 9, 1914)

This article discusses the microscopic effects of smoke and soot as observed upon the air passages and lungs and the association of the resultant pulmonary lesion with those of tuberculosis and pneumonia. Some of the conclusions were as follows: With regard to tuberculosis, the obliteration of the pulmonary lymph spaces in the anthracotic process is unfavorable for the local spread of tuberculosis and aids in the localization of the condition. With regard to acute inflammatory conditions where the lymphatics are important for proper resolution, anthracosis becomes seriously detrimental, because of the obliteration of those spaces.

- 52. Atmospheric air in relation to tuberculosis.** Hinsdale, G. *Smithsonian Inst.* 1914.

The author believes that the "climate may be used as an adjunct of great value for carrying out the hygiene, dietetic treatment of all forms of tuberculosis and of many other diseases." Therefore in keeping our air clean, we can help tuberculosis. The benefits of clean air and sunshine are discussed.

- 53. Smoke in relation to health.** Jacobi, A. *J. A. M. A.* 49: 1813, 1907. (Sept.)

There was an increase in mortality due to bronchitis and pneumonia until 1891-1895, and a considerable decrease since, according to the 66th annual report of the Registrar General of England. L. W. Chubb, in conferences on smoke abatement, reports a decrease in smoke since that time. According to the medical officer of Manchester, the fog days and the mortality rate from acute pulmonary disease have become less.

It appears statistically certain that smoke causes a predisposition to acute pulmonary diseases and accelerates the course of pulmonary tuberculosis. It was also found that in humid atmosphere coal dust was aspirated in larger quantities than in dry weather.

Bartel and Neumann found that tubercular guinea pigs who had been exposed to a moderate amount of smoke died of pulmonary tuberculosis sooner than those which showed smoke-free lungs.

Upper and Lower Portions

- 54. The National Smoke Abatement Conference. Anonymous. M. Officer 76: 206, 1946. (Nov.)**

A report of the proceedings of the National Smoke Abatement Society conference held at Brighton in 1946 is given. The greater part deals with smoke abatement progress and plans for further achievement.

It is reported that the people of Manchester saw the hills for the first time when the general strike of 1926 stopped factory smoke. In that year there were only 991 deaths from bronchitis compared with 1279 in 1925. In the average year in Manchester, one in five cases of sickness is from respiratory disease, and amongst the deaths one in five to six is from the same cause.

- 55. Atmospheric pollution. Anonymous Annual Report, Salford Medical Officer of Health 55, 1934.**

"The sulfurous content of smoke is responsible for much damage to stone buildings as well as to human respiratory passages, and since its deleterious action is greatly intensified by mixtures with adhesive tar and soot . . . it should be limited."

- 56. Regional smoke abatement. Asbury, C. W. J. Roy. Sanit. Inst. 52: 465, 1932. (April)**

Some of the arguments presented for increased smoke abatement are as follows: The lungs of urban dwellers are blackened as are those of the coal miner. The tarry and sulphuric acids set up irritation and play no small part in causation of chronic catarrh, bronchitis, and tuberculosis. By reducing sunshine, smoke indirectly increases incidence of rickets as well as causes a general lowering of vitality. Atmospheric impurities have a large measure of direct responsibility for pulmonary diseases.

- 57. London fogs. Carpenter, A. J. Soc. Arts 29: 48, 1880.**

This article is an informative discussion on smog in London and other industrial areas. It points out clearly the absence of relationship between the usual radiation fog or mist and the dark, dirty, smoky fog (smog) occurring at times over industrial cities. The blame is clearly laid to the burning of soft coal in the homes, rather than to industry, as the chief contributor to the smog. The smog is described as lying close to the ground, very dark, and requiring artificial light on a cloudless day. This is contrasted to mist or fog which does not absorb the light. The loss of sunshine, the corrosion of buildings, and the possible effects on health and life expectancy are mentioned in detail.

58. Our soiled cities. Courtney, W. B. *Collier's Weekly* 1934. (Jan. 27)

This article on the general aspects of air pollution emphasizes its extent, cost, and need for abatement. Darling is quoted as to the bacteria-carrying capacity of smoke, or dusty air, as well as on the irritating effect of the products of combustion on the nose, throat, sinuses, eyes, ears, respiratory tract, bronchial tubes, and gastrointestinal area. "There is a striking parallel between smokiness of cities and a higher pneumonia rate. Cleaning the air of the United States might do as much to reduce pneumonia as cleaning the water did to typhoid." Recommendations are made for improvement in ordinances covering smoke abatement.

59. Action of irritant gases upon the respiratory tract. Haggard, H. W. *J. Indust. Hyg. & Toxicol.* 5: 390, 1924.

"Fundamentally, the toxicology of all irritants is the same; the differences in symptomatology are chiefly the results of differences in the location of their action." An irritant gas causes inflammation of those tissues it contacts. Moist tissues, chiefly the mucous membranes of the respiratory tract and conjunctiva, are most easily penetrated and are most affected. The reaction is physiological, not merely a direct chemical effect. Reflexes are brought into play to protect the different parts of the respiratory tract.

A table gives the relation between the physical properties of irritants and their site of action in the respiratory tract and subsequent symptomatology.

60. Smoke abatement, its effects and its limitations. Meller, H. B. *Mech. Eng.* 48: 1275, 1926.

The purpose of this paper is to show that smoke abatement, as it has been carried out in a number of cities, has been of material benefit to the manufacturer by giving better combustion and lower fuel cost, and to the public by reducing smoke, increasing sunshine, and reducing laundry bills. Anti-smoke laws have been framed, eliminating only a part of the air pollution evil. The contents of the paper also include a description of an anti-smoke ordinance and its provisions, sootfall surveys, and corrective measures to minimize dense smoke.

"Smoke and other items of air pollution fill the atmosphere with acrid, poisonous compounds and soot particles which irritate the sensitive membrane of the eyes, nose, throat, lungs and gastrointestinal tract, increase the susceptibility of gastrointestinal, pulmonary and nasopharyngeal disorders, diminish the potential reserve, working capacity and well-being of the individual, increase fatigue, irritability, and malcontent, and may tend to hasten

premature decay." Smoke content of the air has some bearing on pneumonia death rate and little effect on the tuberculosis death rate.

The intensity of daylight is reduced, shutting out much of the blue and ultraviolet rays of sunshine which normally exert a bactericidal effect on the pathogenic bacteria and a tonic and vitalizing effect upon man.

61. Damage due to smoke. Meller, H. B. Power 68: 734, 1928. (Oct.)

The effects on stone, metals and vegetation are discussed. Of the influence on health, "Cohen states that one adult breathes about 200 gallons of air in 24 hours, or about 34 lbs. in weight, as contrasted with a daily intake of 5½ lbs. of liquid and solid food. There is no question that the solids and gases in the air due to the burning of fuel have an irritating effect upon the eyes, nose, throat and lungs, tending to aggravate or to cause inflammatory diseases of these organs, and to increase susceptibility to certain specific diseases of the respiratory tract."

62. Clean air, an achievable asset. Meller, H. B. J. Franklin Inst. 217: 709, 1934.

This paper supports the contention that air pollution can be eliminated and presents suggestions and recommendations as to how this may be accomplished. Discussed are the needs for clean air, the nature of air pollution (contaminants), and some of the studies and work that have been done, particularly at the Mellon Institute. Effects of smoke are also discussed: destruction of building stones, metals, paints, clothes, and decorations; retardation of the growth of vegetation; formation and prolongation of fogs, certain pathological effects due to inhalation of solid particles and decreased sunshine. "Medical specialists have informed us that inspired airborne impurities irritate the sensitive membranes of the eyes, nose, throat, and lungs, and thus aggravate or cause various maladies of those organs, or increase their susceptibility to acute diseases of the respiratory tract. These pollutants also enter the gastrointestinal tract and may induce systemic poisoning."

63. Smoke plague of large cities. Rubner, M. Arch. f. Hyg. 58: 323, 1906. (Abstr. Mellon Inst. Smoke Invest. Bull. No. 9, 1914)

This author believes that while there can scarcely be any doubt of the possibility that the smoke content of the air is an important element of injury to health, a matter of the coincidence of bad air and disease is another matter. "Such a proof can scarcely be attained even by the standard of very exact etiological investigations. If there is an entire lack of knowledge as to how the pollution of the

air by smoke is distributed in the country in general, and as to whether the regions with impure air coincide to some extent with those of more frequent lung diseases, there is still further lack of proof as to whether the condition of the air alone is responsible for the injury, or whether the remaining within doors does not also contribute to it. The injuries resulting from a pollution of the air might also be traced to climatic influences."

64. The contamination of the air of our cities with sulfur dioxide, the cause of respiratory disease. Schaefer, T. W. Boston Med. Surg. J. 157: 106, 1907. (July)

The author had, for the ten previous years to 1907, studied the noxious effect of sulfur dioxide, and he concluded that it is one of the most patent causes of asthma. It is estimated that for every ton of coal burned, 3 tons of sulfur dioxide are formed. Sulfurous acid is formed from sulfur dioxide, and this is very detrimental to buildings and vegetation. "It is a well-recognized fact that, during periods of heavy fogs in manufacturing centers, the morbidity and mortality from respiratory diseases are increased very greatly, and that, as the atmosphere clears, a sharp decline follows." Sulfur dioxide is a local irritant producing coughing, bronchitis and pneumonia. Kiohna discovered, in his experiments with sulfur dioxide in rabbits, that the pulmonary capillaries were seriously damaged and the blood itself underwent chemical change. He believes that sulfur dioxide is a protoplasmic poison. He observed that long-continued, small doses affected the lungs seriously. Sulfur dioxide inhaled by some people will produce or bring on attacks of asthma.

"The various diseases of the air passages, including pharyngitis, bronchitis, pneumonia, and asthma, are materially influenced by meteorological conditions."

Legislation and prevention of the pollution of the air are suggested by the author.

65. The effects of coal smoke of known composition on the lungs of animals. Schnurer, L. and Haythorn, S. R. Am. J. Path. 13: 799, 1937. (Sept.)

Pulmonary fibrosis due to, or associated with, silica dust in occupational groups predisposes to tuberculosis, while fibrosis due to pigmentation in nonoccupational groups does not. The opposite appears to be true of pneumonia.

The method used in the experiment is described. On autopsied rabbits and rats, bronchopneumonia and purulent bronchitis were encountered. The peribronchial lymph nodes were enlarged and blackened. Polymorphonuclear leukocytes and mononuclear cells were present. In areas of darkest pigmentation, the alveoli had

collapsed. The walls of the collapsed alveoli were congested, thickened, and filled with mononuclear cells and leukocytes. Animals killed 103 days after the termination of the experiment showed fibrosis.

The authors believe that "carbon" was responsible for both the pneumonitis and the fibrosis.

- 65a. Dust storms and their possible effect on health. Brown, E. G., Gottlieb, S. and Laybourn, R. L. Pub. Health Rep. 50: 1369, 1935. (Oct. 4)**

This is a brief report of the "dust storms" which, because of drought and other factors, affected the west-central part of the United States in the early months of 1935. The dust was so thick on some days as to completely obscure normal daylight.

Although no pathogenic organisms were found in the dust, serious increases in respiratory disease incidence occurred. These are ascribed to the irritating quality of the siliceous nature of the dust. The particle size of the dust was rather large, significantly larger than silica particles capable of reaching the lung parenchyma. The evaluation of the increased incidence of respiratory disease was based on mortality as well as morbidity data.

Bones

- 66. Atmospheric pollution by coal smoke; the practical issue. Jervis, J. J. J. Roy. San. Inst. 50: 411, 1929-30. (Dec.)**

This is a discussion on points of view of the industrialist and scientist with regard to matters concerning atmospheric pollution by smoke. Present laws governing smoke abatement are discussed with particular emphasis on their inadequacy. The general theme is that abolition of smoke is necessary not only from the health aspect but also from the various economic aspects.

It is considered indisputable that smoke in the atmosphere contributes to the incidence of rickets, tuberculosis, anemia, and wasting and crippling diseases of childhood.

The greater use of low temperature coke by the domestic user is encouraged.

Skin

- 67. Dermatitis venenata caused by smoke. Landor, J. U. Brit. J. Dermat. 55: 17, 1943. (Jan.)**

Skin lesions were the result of exposure to smoke from burning Binjai firewood.

- 68. Los Angeles seeks to halt smog. Anonymous. Indust. Hyg. Digest 11: 1, 1947. (Oct.)**

Unlike other cities, Los Angeles has an atmospheric problem mainly attributable to industrial fumes rather than to coal dust and smoke. The accumulation sometimes reduces visibility to less than a mile and is extremely irritating to the eyes and nasal passages.

Stricter, more pointed legislation has been passed in an effort to correct this situation.

- 69. Relation of smoke-laden atmosphere to diseases of the eye. Fox, L. W. J. A. M. A. 47: 384, 1906. (Aug.)**

The author noted an increase in the number of patients with external eye disease during the previous three years and attributed this increase to the coal dust laden atmosphere caused by the substitution of soft coal for hard.

- 70. Physiological studies of irritant aspects of atmospheric pollution. Roth, H. P. and Swenson, E. A. Office of Air Pollution Control and University of Southern California, School of Medicine, Los Angeles, 1947. (Oct.)**

The study was made to determine threshold levels for eye irritation from formaldehyde. Some persons were sensitive to concentrations as low as 0.25 parts per million, while others did not experience irritation until concentrations of 5 to 10 parts per million were reached. Older persons were more sensitive than younger ones. Increased humidity raised threshold for irritation.

- 70a. The smog problem in Los Angeles County. Anonymous. Second Interim Report, Stanford Research Institute, Palo Alto, California, 1949.**

This is an overall report of the study of air pollution in Los Angeles, California. It contains a section on eye irritation, the one symptom which has caused the greatest degree of public clamor in that area.

It appears that eye irritation is most marked when the relative humidity is relatively low (25-30 percent), and is especially marked between 9 a.m. and 12 noon. Studies of incidence have been based on interviews with persons on the street.

A new contrivance was developed to assist in determining the causative agent. This involves a mechanism whereby irritant materials are introduced into a closed-goggle system, and the rate of blinking (blink-rate) is recorded via the use of the interruption of a light beam noted by a photoelectric cell. A chamber has also been devised to hold persons whose senses may all be affected by the gas introduced into the chamber.

Thus far, the exact individual agent responsible for the irritation of the eyes has not been identified. It appears that the irritant effect is due to a combination of substances which may, possibly, have a greater action than only a summation effect. Thus far aldehydes, organic peroxides, elemental sulfur, and oil mists have been tested as possible causative agents.

Cancer

Lungs

71. **Smoke-laden atmosphere and cancer: increasing lung cases may be due to atmospheric pollution.** Anonymous. *Chem. Age (London)* 31: 308, 1934. (Oct.)

The experiments showing the cancerigenic effect of tar suggests the cancerigenic effect of a smoke-laden atmosphere. The increased incidence of lung cancer is cited. Rickets and tuberculosis show an increased incidence where sunlight is diminished by a smoke-laden atmosphere. Methods of smoke concentration detection and recommendations for control are discussed.

72. **The effects of exhaust gases from internal combustion engines and of tobacco smoke upon mice, with special reference to incidence of tumors of the lung.** Campbell, J. A. *Brit. J. Exper. Path.* 17: 146, 1936. (April)

Mice were exposed in this experiment to exhaust gases in some cases, and tobacco smoke in others, for periods covering the greater part of their lives. It was hoped to find some significant factors at necropsy which differentiated the exposed animals from controls. Details of the experiment are given.

The exhaust gases and tobacco smoke did not produce any marked effect upon the general health. There seemed to be some increase in the incidence of primary lung tumors as the result of exposure to exhaust gas from the automobile consuming gasoline which contains tetraethyl of lead, and also as the result of exposure to cigarette smoke. The increase is insignificant compared with effects of exposure to tarred roads reported by Campbell. The difference between mice lung cancer and that in man is discussed.

73. **Carcinoma of the lung.** Hueper, W. C. *Illinois M. J.* 56: 296, 1929. (Oct.)

"Dust and smoke, especially coal and quartz, which produce an anthracosis and chalicosis of the lung with resulting chronic interstitial pneumonia and chronic bronchitis with secondary regenerative metaplastic changes and proliferations of the bronchial mucosa and alveolar epithelium are considered by many as etiologically important factors and are regarded by them as causative

agents which are responsible for the recent marked increase in frequency of lung tumors . . ." Others do not believe that smoke and dust are factors in increased incidence of lung cancer. Inhalation of vapors of acids and alkalies is suggested as the possible causative agent in lung cancer.

- 74. Smoke, the silent menace.** Am. Osteo. Assn. A special feature radio program over KSD St. Louis, July 19, 1949. Speakers—Levitt, A.; Carter, J. H.; and Eggleston, A.

An excess of atmospheric smoke leads to serious respiratory diseases. Smoke is related to many degenerative diseases. Smoke definitely contains chemical substances which contribute to cause certain types of cancer. Fly-ash causes irritation and tissue changes in the lungs, and it is suspected that these lung changes predispose to pneumonia, tuberculosis and cancer. It is known that, in areas polluted by coal smoke, respiratory diseases are of high frequency. Pneumonia causes six times more deaths in industrial areas than rural. Chemicals released by combustion of coal are capable of producing cancer of the lung and other body tissues. Air pollution in New York City has increased 40 percent in the past 10 years, and cancer of the respiratory system has increased from 686 cases in 1936 to almost 2,000. J. H. Carter asserts that the smoke abatement program in St. Louis has decreased cost of upkeep of buildings, decreased electricity costs, and increased civic pride. A. Eggleston discusses atmospheric pollution in Montreal and the program for smoke abatement.

- 75. Respiratory tract cancer deaths in relation to atmospheric pollution in Cincinnati.** Mills, C. A. Cincinnati J. Med. 27: 692, 1946. (Oct.)

Fifty years ago in London, chimney sweeps had a high incidence of skin cancer on the exposed areas. "Slightly under 100 Cincinnati people die each year from cancer of the respiratory system, and this deadly affliction strikes most frequently among the unfortunate people who must reside in the parts of the city where atmospheric pollution is greatest." Males are involved five times as frequently as females.

A chart is used for comparison of the respiratory tract cancer deaths per 10,000 males for a five-year period with the average carbon deposit per month in different parts of the city. "In general, the cleaner suburbs of the city have low respiratory cancer rates, while the more industrialized, low lying districts have higher rates. This is the same relationship as was found for pneumonia and pulmonary tuberculosis. There seems to be little doubt about the high price we pay in respiratory disease and death as a result of atmos-

pheric pollution in certain parts of Cincinnati." Remedial steps are given.

76. **Primary carcinoma of the bronchus, its pathology, symptomatology, diagnosis and treatment with an analysis of 67 cases.** Muller, G. and Miller, B. J. *Clinics* 4: 42, 1945. (Abstr. Biol. Abstr. 19: 21807) (June)

"Primary lung carcinoma is definitely on the increase. The incidence is higher in the male. Some etiological factors in lung cancer which have been considered are: the inhalation of particles of chromium, lead, silica, radioactive ores, light oil derivatives of coal tars, smoke of tobacco and industrial smoke . . ."

77. **Cancer and toxic gases.** Pessano, J. E. *Semana méd.* 2: 210, 1942. (Abstr. C. A. 37: 677, 1943) (Feb.)

"Among the products of combustion from gasoline motors some belong to the group of compounds considered to be carcinogenic. Rats respiring products of combustion of petroleum at high concentrations developed carcinoma of the lungs with widely distributed metastases. Ingestion of the black deposit formed by the combustion produced a papillomatous hyperplasia of the gastric epithelium, ulcers of the mucosa and hyperplastic development of the glands. The liquid products formed by combustion of petroleum when applied to the skin of rabbits produced malignant tumors. The danger of soot is pointed out."

78. **Existence of hydrocarbons in city air, importance for pulmonary cancer.** Roffo, A. H. *Bol. Inst. de Med. exper. para el estud. y trat. d. cancer* 16: 297, 1939. (Aug.) (From English summary)

Samples of atmospheric air in the city of Buenos Aires submitted to spectrographic studies revealed substances with the same spectrum and the same fluorescence characteristic for certain non-saturated, polycyclic hydrocarbons. These latter are considered analogous to the products of incomplete combustion of petroleum products, which are shown by the author to be carcinogenic. The author then stresses the danger of the production of lung cancer by an atmosphere in which wastes of motors are emptied. He also alludes to the carcinogenicity of tobacco tar.

79. **Coal smoke soot and tumors of the lungs in mice.** Seelig, M. G. and Benignus, A. B. *Am. J. Cancer* 28: 96, 1936.

One hundred mice were subjected to an atmosphere of soot, and fifty mice were used as controls under normal laboratory conditions. Autopsies were performed on the mice as they died. Twenty-one percent of the experimental animals developed hyperplasia of the bronchial epithelium. In this experiment, cancer of the lung in the

experimental group was four times as great as in the control group.

There is a two-page table of deaths due to cancer of the lungs in the rural and urban areas of each state of the United States from 1930-1934. It is interesting to note the consistent and markedly higher death rates in cities. From known data, the author concludes or suggests that there is some relation between primary pulmonary cancer in cities and smoke and soot.

- 80. Does smoke cause cancer? Studies in medical and population subjects, No. 1. Regional and local difference in cancer death rates, 1947. Stocks, P. Smokeless Air No. 65: 11, 1947. (Abstr. Air Poll. Bull. 16: No. 1, 22, 1948)**

The author finds that the mean annual hours of sunshine "significantly correlated with death rates from lung cancer, bronchitis and tuberculosis, for which the strength of the correlation appears to be much greater for lung cancer than for the other lung affections." Either smokiness of atmosphere is an important factor in itself in producing cancer of the lung, or sunshine is an important factor in preventing its incidence.

Skin

- 81. Carcinogenic agents present in the atmosphere and incidence of primary lung tumors in mice. Campbell, J. A. Brit. J. Exper. Path. 20: 122, 1939.**

Tarry matter from roads as well as chimney soot both have been proved to produce skin cancer. Carbon in the soot mitigates this action somewhat, and inorganic substances in tarry matter aid the production of skin cancer. The tarry matter of cigarette smoke after prolonged periods of time can produce skin cancer. Soot from auto exhaust has little carcinogenic effect.

The dust from tarred roads seems to be the most dangerous source of carcinogenic agents; when inhaled it gives the highest cancer incidence in mice.

General

- 82. Investigations on wood smoke (carcinogenicity). Anonymous. Annual Report British Empire Cancer Campaign 18: 113, 1941.**

A study was made of the parallelism between gastric cancer incidence and the use of smoked food. The study concluded "that wood smoke, as used for the preservation of human food, contains no carcinogenic compounds which can be detected by its effect on the skin of the experimental animals used."

- 83. Investigation into the possible carcinogenic activity of wood smoke.** Dickens, F. and Weil-Malherbe, H. *Cancer Research* 2: 680, 1942. (Oct.)

The experiment conducted with wood smoke condensates on mice is of interest in that essentially no local tumors developed on the skin where the materials were rubbed. In another experiment, rats were fed smoked foods, and no neoplasms developed. Many reasons are suggested for this "apparent failure" to produce cancer with smoke products.

- 84. A study in degenerative diseases, including cancer.** Levitt, A. *J. Am. Osteo. Assn.* 47: 135, 1947. (Nov.)

There is a high incidence of cancer and other degenerative diseases in areas at outlets of navigable rivers and in low washed-out valley lands; e. g., industrial areas. Adequate smoke control would lessen the concentration in the atmosphere of airborne carcinogenic hydrocarbons caused by smoke and steam.

- 85. Cancer death rates, smoke and topography.** Meyers, J. *Am. J. Pub. Health* 20: 581, 1930. (June)

There is a variation of cancer deaths in different countries. Green's work in England and Scotland seems to point to a distinct influence of topography and of fuel combustion products on cancer death rates. Other data indicate the influence of smoke and fumes or tar on cancer.

- 86. Air pollution and the rising incidence of cancer.** Mudie, E. C. *J. Roy. San. Inst.* 52: 292, 1932. (Jan.)

Cancer is said to be caused by the continuous mechanical and chemical irritation of poisonous agents, spread over a length of time, combined with light starvation. Soot and tarry particles are considered carcinogenic. Not only respiratory but also uterine, breast, scrotal and other forms of cancer may be caused by soot.

- 87. The carcinogenicity of wood soot from the chimney of a smoked sausage factory.** Sulman, E. and Sulman, F. *Cancer Research* 6: 366, 1946. (Abstr. C. A. 41: 200, 1941) (Jan.)

"Consumption of smoked sausage for two years did not cause tumors in 20 adult rats. However, the wood smoke used for its preparation contained substances that were carcinogenic on subcutaneous administration in rats and on cutaneous application in mice. Of 18 female rats implanted subcutaneously with fragments of the soot from the factory chimney, three developed sarcoma, and of all 10 female mice rubbed on the back of the neck with an alcohol-extract of the soot daily for two years, one developed carcinoma and two sarcoma. No tumors developed in 18 male rats inoculated intrascrotally with soot fragments."

- 87a. A physician's view of air pollution. Hussey, R. Presented at the 14th Annual Meeting of Industrial Hygiene Foundation, Pittsburgh, 1949.**

This is a general presentation of the problem. Stress is laid on the lack of information about the effects of long-continued exposure to low concentration of air pollutants. There is need for study of this latter matter. The author suggests that data are lacking of the relationship of cancer to air pollutants.

Psychological

- 88. Smoke and individual health. Clark, R. V. J. Roy. San. Inst. 50: 394, 1929. (Dec.)**

The pollution of the atmosphere with smoke produces gloom, which in turn has a psychological effect upon the people. Sunlight is necessary for both mental and physical health. The tar, acids and carbon of smoke damage the lungs as well as produce cancer.

England has a Smoke Abatement Law with rigid enforcement and severe penalties for violators.

- 89. City smoke injuring the brain. Meller, H. B. Literary Digest 115: 25, 1933. (March)**

"It is not possible to recognize definitely any acute mental disorders or specific disability, yet the process of slow smoke-poisoning may work insidiously on the vital tissues, making it impossible for the brain to function at maximum efficiency."

- 90. Smoke abatement from the point of view of public health. (Edinburgh Section: Smoke Abatement) Chem. Age (London) abstr. 33: 333, Oct. 1935.**

"... statistical evidence showed a close relationship between death rates and atmospheric conditions. Psychological ill-effects were interrelated with the physiological; smoke gloom lessened the potential reserve, working power and well-being of the individual; it increased fatigue, irritability and restlessness; gloom induced mental depression."

Pastures in the neighborhood of industrial towns at one time could feed two cows per acre; now only one per three acres can be fed, and the cow's milk is deficient in calcium. This deficiency causes rickets in children.

- 91. The ill effects of smoke on health and comfort. Stoner, J. B. Mil. Surgeon 32: 372, 1913. (April)**

The author reasons that the gloom created by smoke makes a family irritable and that in order to get away from this unpleasant situation, the men take to the saloon. "The effect of smoke on temper, and ultimately on temperament, has proved to be dis-

astrous." Much of the discussion on health is taken from the psychological point of view and centers around the depressing effect of gloom and smoke.

Because the poor people cannot get out into the country air, the author states, there is a higher percentage of pulmonary diseases in them than in those who live in or have a vacation in the country. "Statistics show that there are more people subject to nasal throat and bronchial troubles in a smoky city than in a comparatively clean town. There are also more fatalities from pneumonia, diphtheria and typhoid fever owing to the lowering of vital forces as a result of scarcity of sunshine caused by heavy fogs of smoke."

92. Psychological aspects of the problem of atmospheric smoke pollution. Wallin, J. E. W. Mellon Inst. Smoke Invest. Bull. No. 3.

The pathology of smoke: Principal portal of entry for soluble inhaled particles is reportedly via the alimentary canal rather than respiratory tree. An increased morbidity and mortality to tuberculosis and pneumonia is cited for smoke-laden areas. Smoky atmosphere is blamed for a high incidence of a feeling of depression in people living in smoky industrial areas. Smoke produces meteorological variations which then further affect the well-being; e. g., loss of sunshine, increasing humidity and fog, increasing intensity and duration of fog, decreasing visibility and higher temperature. Pathological effects include a decrease of erythrocyte count and a decrease of hemoglobin. There is considerable discussion of the various mental effects of darkness and gloom as contrasted to light and sunshine.

Non-Specific Health Effects

93. Smoke menaces health. Anonymous. Indust. Health Bull. 2: 1, 1946. (Abstr. Atmos. Poll. Bull. 15: 15, 1947) (July)

The health hazards of air pollution are cited and are shown in comparison with morbidity and mortality figures. Smoke abatement measures are considered. It is thought that a large proportion of the solids contained in city air could be eliminated by proper operating practice.

94. City smoke and its effects. Anonymous. Pub. Health Rep. 51: 15, 1936. (Jan.)

Smoke causes economic losses (soils merchandise in stores, necessitates more frequent dry cleaning of clothes and repairing and repainting of buildings), injures vegetation (grass, shrubs, and trees),

and exerts a possibly harmful influence on health through the loss of daylight and ultraviolet light.

95. Smoke prevention and public health. Anonymous. Engineering 19: 426, 1900.

"The wholesale poisoning of the air by coal products and the consequent obscuration of the sun and absorption of oxygen, is a direct danger to every individual and, if permitted to go far enough, would doubtless result in the final extinction of the human race. The influence of smoke upon public health is shown in the fact that there is no record of smoke-producing towns keeping up a natural increase in the population, the increase in population of cities being maintained at the expense of the country." The author agrees with Priestly, who claims that a certain amount of smoke is not preventable. He believes that, since the manufacturer will not realize economy by preventing production of smoke, any regulation of smoke will depend upon the degree to which the manufacturer is legally prevented from polluting the air.

96. Presidential address on smoke abatement. Asbury, C. W. J. Roy. San. Inst. 50: 389, 1929. (Dec.)

The harmful effects of air pollution are enumerated: pulmonary disease, rickets, diminished farm crop yield, poorer quality of all farm products, toxic effects on plants, and deterioration of buildings. The indifference of the populace and officials to the problem is stressed. Governmental action on a national scale throughout England is urged. Improvements for industrial and domestic heating equipment for old and new establishments, as well as increased use of smokeless fuels, are suggested.

97. Atmospheric smoke pollution and its relation to public health. Bloomfield, J. J. J. Outdoor Life 25: 457, 1928. (Aug.)

The author summarizes the current knowledge regarding smoke pollution and its effects. A review of the literature leads him to conclude "that it is indeed difficult to show the influence that atmospheric smoke exerts on public health."

Smoke is defined as the mixture of flue gases and suspended particles of solid or liquid matter which are produced by certain fuels during the process of combustion. The direct effects of smoke are difficult to assess. It is difficult to prove a direct relation between smoke pollution and the death rate. Too many other factors are present which could contribute. Smoke indirectly affects health through reduction in sunshine. This loss and its effects are even more elusive of proof. It is concluded that smoke is but one of the possible factors contributing to the death rate in cities.

- 98. Recent advances in public health. Buon, J. L. Smokeless Air, Autumn-Winter 1947. London: Churchill (Abst. Atmos. Poll. Bull. 15: 18, 1948) (Mar.)**

"One chapter is devoted to smoke prevention. Domestic and industrial problems are reviewed, and there is a summary of the main effects of smoke. The importance of health education in smoke prevention is stressed, and an account of practice in the United States is included."

- 99. Atmospheric pollution in relation to health. Clark, R. Gas J. 178: 504, 1927. (May)**

The author believes that the polluted atmosphere and crowded conditions of Manchester, as compared to the relatively clean air in sparsely populated rural areas, are contributing factors to the high death rate.

- 100. The injurious effects of smoke, dust, and toxic gases. Humery, R. Mém. soc. ing. civils France 92: 364, 1939. (Abst. C. A. 34: 7475, 1940) (Nov.)**

The author discusses the injurious effects of the solid and gaseous constituents of smoke, especially sulfur dioxide, on the human organism and on buildings.

- 101. Atmospheric pollution and the need for greater interest in its abatement. Jahr, H. Gesundh. Ing. 51: 497, 1928.**

The noxious gases in smoke are of sufficient importance to health to warrant more consideration to their control. Concentrations of some gases are given, and their general effects on health are discussed.

- 102. Smoke abatement in the City of New York. Levitt, A. Letter to William O'Dwyer, Mayor of New York City, dated June 1, 1948. (Mimeographed)**

Closely related to atmospheric pollution are such affections as tuberculosis, chronic illness, heart disease, cancer, arthritis, and diabetes. The cost of sanitation, decorating, and cleaning is also increased by air pollution.

Suggestions for adequate smoke abatement in the City of New York include: (1) enforce efficient smoke control regulations, (2) burn smokeless fuel, (3) inspect fuel and fuel-burning equipment and provide the necessary instructions. The successful smoke regulatory program of St. Louis is cited.

- 103. A doctor looks at smoke and dust. McFarland, W. W. Scientific American 150: 66, 1934. (Feb.)**

Smoke abatement problems and progress are commented on briefly. The author reports on the work of the New York City Department of Health, which, according to him, demonstrated a positive correlation of high smoke content of the air and incidence

of cancer. On the physiological effects of smoky air, he observes that "it is easier for the average man to keep up his bodily resistance to disease and to maintain vigor when he is making direct contact with strong sunshine and is breathing air of little dust content."

104. Air pollution in Pittsburgh. Meller, H. B. Pittsburgh M. Bull. 14:14, 1925. (Aug.)

General comments on air pollution in Pittsburgh are discussed, including a statement of the problem, the Mellon Institute study, the Ringelman chart, and general results to date of legislation enacted against smoke. The author feels too much stress is placed on solid particles and not enough on abatement of the noxious gases.

Evil effects of polluted city air are thought to be irritation of the membranes of the eyes, nose, throat, lungs and gastrointestinal tract; diminished potential reserve, working capacity and well-being of individuals; increased fatigue, irritability and malcontent, and hastened premature decay. Smoke and other impurities have an important bearing on the pneumonia death rate but a comparatively little effect on the tuberculosis death rate. Smoke reduces the intensity and duration of sunshine, resulting in reduced visibility; it also increases humidity, mists, frequency and duration of fogs and possibly alters the electric potential. The benefits of sunshine's bactericidal and vitalizing influence on man are thereby reduced. Anabolism, transpiration, respiration and percentage of hemoglobin are also affected by the reduction or loss of sunshine. Dark clouds also have a depressing, devitalizing effect. Increased humidity increases exposure to suspended noxious gases.

105. Damage due to smoke. Meller, H. B. Trans. Am. Soc. Mech. Engrs. 50: 213, 1928.

This report reviews the work of the Mellon Institute Smoke Investigation of 1913, including additional later observations and data to indicate results of studies since 1913. Discussed are meteorological aspects; effects on stone, metals, outside painting and interior of buildings; effects on vegetation, influence on health; and economic cost.

106. Some hygienic aspects of the air pollution problem. Meller, H. B. Pittsburgh M. Bull. 20: 793, 1931. (Nov.)

The source, contents, and health implications of atmospheric pollution are discussed.

The effects are considered as direct and indirect. Direct effects are due to the inhalation of contaminated air. The solid particles which are inhaled can irritate the sensitive mucous membranes of the respiratory tract. Indirect effects are due to the shutting out of sunshine, particularly the shorter wave lengths. This loss,

coupled with increased incidence of smog, dark clouds and mists, leads to a psychologically depressed mental state.

107. Warring on city smoke and dust. Meller, H. B. Progress 1: 11, 1933. (April)

The author seeks to stimulate interest in smoke abatement. General effects of smoke, such as loss of sunshine and clean air, important health factors, are mentioned.

108. City air pollution and its control. Meller, H. B. Aerologist 9: 5, 1933. (Feb.)

Written for the lay reader, this resume of the air pollution problem includes a discussion of control of combustion, physiologic and economic effects of pollution and regulatory recommendations. Possible dangers to health, as well as less tangible results difficult of proof, are broadly covered.

109. Smoke-abatement investigation at Salt Lake City, Utah. Monnett, O., Perrott, G. St. J. and Clark, H. W. U. S. Dept. of Commerce, Bur. of Mines Bull. 254, 1926.

Conclusions of the Chicago Association of Commerce through its committee of investigation on smoke abatement on effects of atmospheric pollution were as follows:

I. Health

1. There is a general agreement among sanitary authorities that polluted air is harmful to health.

2. At the present time there is no accurate method of measuring this harm nor of determining the relative responsibility of the different elements that enter into the mixture of gases and solids commonly referred to as atmospheric air.

3. The direct effect of smoke or any of its attributes, including soot, dust, and gases, in amounts which may ordinarily pervade the atmosphere of a smoky city is not shown to be detrimental to persons in normal health.

4. The direct effect of smoke upon those who are ill has been most extensively studied in connection with tuberculosis and pneumonia. It appears that smoke does not in any way stimulate the onset of tubercular processes nor militate against the rapidity of recovery when once this disease has been contracted. In cases of pneumonia, the effect becomes seriously detrimental.

5. In addition to these direct effects, indirect effects result from the diminution of sunlight and the increase in fogs, clouds, and haze.

6. The general physical tone is lowered as the result of long continued breathing of polluted air.

II. Vegetation

In summary it was concluded that smoke excited injurious effects

on vegetation directly via poisonous gases or indirectly as result of fogs. Effects are not specific, and the amount of smoke necessary to produce damage was non-determinable.

- 110. The smoke nuisance.** Niven, J. *Pub. Health* 3: 236, 1890-1891. (Abstr. Mellon Inst. Smoke Invest. Bull. No. 9, 1914)

A medical health officer writes, "Manchester is still conspicuous for its high mortality, and it is especially conspicuous for its excessive death rate from tuberculosis, pneumonia, bronchitis, and heart disease. All forms of septic disease are unduly prevalent. The windows of houses and factories are closed on account of the dirt which enters by the open window. Less attention is paid to cleanliness than is needful for health. Fresh air is needed not only in the treatment of consumption but is equally necessary for the raising of healthy children. The mouth breather is at a much greater disadvantage in Manchester than he is in the country, and it is important that adenoids are attended to."

- 111. Dust and fume, foes of industrial life.** Oliver, Sir T. *Lancet* 183: 865, 1912. (Sept.)

Some of the industrial conditions which are prejudicial to health are considered. Statistics on industrial accidents and deaths are cited. On the effect of smoke on lung diseases, the conclusion is drawn that a smoke-polluted atmosphere predisposes to acute lung diseases and hastens the course of tuberculosis. Dust from tarred roads is accused of (1) damaging foliage by blocking stomata and thereby causing stunted vegetation, (2) killing trout in streams, (3) reducing the number of birds because insects are scarcer, and (4) increasing lung disease, particularly tuberculosis, among street sweepers. The social influence of air impurities, such as increased filth and grime, is discussed. Other aspects considered are explosions in mines and industrial dusts.

- 112. The smoke question viewed from a national viewpoint.** Reed, C. A. L. *Am. Med.* 9: 703, 1905. (April)

Generalizations are made with regard to the effect of smoke on health. No substantiating evidence or statistics are included. Recommendations are made for smoke abatement on a national scale rather than on a local level.

- 113. The smoke plague.** Rolleston, Captain C. *Westminster Rev.* 168: 155, 1907.

The smoke problem is one of esthetics, discomfort, pecuniary loss, and public health. "A large part of London is now unfit for human habitation." The air contaminants are obnoxious and to a certain extent poisonous. The sulfurous gases, hydrocarbons and carbon dust have been proved to have an adverse effect on the

respiratory organs. "It is not surprising, then, that bronchitis, pneumonia, and kindred other complaints are very common. Tuberculosis, is doubtless largely intensified by inhalation of the smoke laden air." Loss of health also occurs because of reduced sunshine. In the vicinity of large towns, crops, trees, and vegetation in general suffer. Each year it is increasingly difficult to grow trees, roses, and other plants. The annual savings through more complete and intelligent combustion of coal, with consequent reduction in smoke, is discussed at length.

114. Pollution of the city air as a source of nose and throat disturbance. Ruskin, S. L. Science 84: 84, 1936.

Air pollutants are principally sulfurous gases. Others are hydrochloric acid, chlorine, hydrofluoric acid, oxides of nitrogen, ammonia, hydrogen sulfide, carbon disulfide, carbon monoxide, formaldehyde, and hydrocyanic acid. The source for oxygen is principally the result of plant life and actinic sun rays. Plant life may be a measure of air pollution, as plants are more susceptible than humans. Meteorological aspects are discussed since calm days tend to concentrate dust and smoke over the exposed areas. Presence of dust or soot is necessary for condensation of moisture to produce fog. Reduction in the temperature and the absence of wind are also factors in its production. Fog then is a source for prolonged inhalation of noxious influences. There is produced a prolonged irritation of the respiratory tract with an increased susceptibility to respiratory infections.

The author stresses the importance of city planning with regard to prevailing winds, so that the location and number of industrial stacks, as well as volume of gas expelled therefrom, may be controlled.

115. Clean air and practical politics. Seward, A. C. J. Roy. Sanit. Inst. 64: 185, 1944. (Oct.)

This discussion centers around the importance of clean air and the lack of public concern at Bolton, England. The increased death rate from respiratory diseases in smoky towns is stressed, as also are the generally unhealthy effects of reduced sunshine. Recommendations include: (1) A national publicity campaign; (2) local records of air pollution; (3) licensing of stokers; (4) laws governing boiler equipment; (5) control of fuel; (6) approval before installation of new plants with regard to abatement equipment and policies; and (7) employment by health department of sanitary inspector.

116. On the air of towns. Smith, R. A. J. Am. Chem. Soc. 11: 196, 1859.

This comprehensive article concerns atmospheric pollution in

towns. Methods of combustion of coal and its by-products are tabulated. Sulfur acids produced cause stunting of the growth of trees. The acidity of the air at times is so great as to turn litmus paper red immediately during a rain. Estimations of carbonic acid and organic matter in air are discussed. The death rate is higher in urban areas than rural because of atmospheric pollution.

Based on experiments in which polluted air was bubbled through blood, the conclusion is that "the atmosphere of a town has a peculiar effect on the state of the blood . . ."

- 117. Medical aspects of the smoke problem.** Taylor, J. M. *J. A. M. A.* 47: 383, 1906. (Aug.)

All who are ill are made more susceptible to complications, and their recuperative powers are impaired, by a vitiated atmosphere. Laws governing the smoke problem should be more adequately enforced.

- 118. Bituminous coal smoke; its chemistry and effects on the health of man and plants, works of art and commerce.** Wainwright, J. W. *M. Rec.* 84: 791, 1908.

This article includes a discussion of the detrimental effects on health caused by smoke and its constituents.

- 119. What is known about the effect of smoke on health.** White, W. C. *Safety Eng.* 53: 81, 1927.

The physiological effects of smoke are reviewed. Experiments carried out in Pittsburgh seemed to indicate that the breathing of smoke-laden air has no demonstrable influence on the prevalence of tuberculosis but has a definite relation to the high pneumonia mortality and the incidence of acute respiratory diseases.

- 120. Subjective reactions of human beings to certain outdoor atmospheric conditions.** Winslow, C.-E. A. and Herrington, L. P. *Heating, Piping Air Conditioning* 7: 551, 1935. (Nov.)

The pleasantness of outdoor atmospheric conditions, as evidenced by the opinion of a group of some 80 persons taken each morning for a year, is chiefly influenced by sunshine, next by relative humidity and total ions. The total ions present in the air are largely made up of the gaseous products of combustion.

Doubt of Health Effects

- 121. Air Pollution.** Anonymous. *Am. J. Pub. Health* 38: 761, 1948. (June)

This is a report on the source, character, effects and methods of control of atmospheric pollution. Smokes that result from the combustion of fuel contain soot, fly ash, and unburned or partially

burned fuel. In excessive quantities, smoke is disagreeable, discomforting, and of economic significance, but the evidence so far collected has not been able to establish a definite relationship between smoke and health. Mucous membrane irritants include sulfur dioxide, chlorine, and phosgene. Eye irritants are acrolein, butadiene, chlorine and hydrogen sulfide.

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122. The smog problem in Los Angeles County. Report on the first 12 months of research by the Stanford Research Institute. Committee on Smoke and Fumes, Western Oil and Gas Association, 1948.

"'Smog,' as the word is used in the Los Angeles region, denotes a peculiar set of weather conditions in which natural haze and man-made contaminants of the air mingle to produce an unpleasant, murky atmosphere." The object of the study was to find out what smog is and where it comes from.

Smog reduces visibility and causes irritation of the eyes, nose and throat. Smogs in the Los Angeles region have increased in number in recent years. The geographical location of Los Angeles and the mechanism of the smog are explained. A technique for forecasting smoggy weather has been evolved. The problem of eye irritants in smog was simulated in a specially-constructed chamber. It was tentatively concluded that elemental sulfur, together with acrolein and hydrogen sulfide, could produce eye smarting characteristically as could the smog. A search was made for the possible sources of eye irritants. Reduced visibility and its causes are discussed.

123. The smoke problem and public health. Coplin, W. M. L. J. A. M. A. 47: 384, 1906. (Aug.)

"Regarding the influence of the smoke on public health, the statistics are confusing and incomplete." There has been much disagreement among investigators on the influence of smoke on pulmonary structures . . . there is little evidence to show that the presence of smoke in the air increases especially the morbidity or the mortality of a community."

124. Address on the smoke nuisance and its abatement before the industrial Society of Hamburg, 1890 (Pub. not given) Glinzer, C. (Abstr. Mellon Inst. Smoke Invest. Bull. No. 9, 1914)

The writer, while regarding smoke as truly injurious to health in a degree not as yet determined, appreciated twofold qualities. Smoke, he believes, possesses excellent germicidal and disinfecting properties. "Obnoxious vapors and other harmful products carried by the air are absorbed and retained by the material elements of smoke and are finally carried away harmlessly by the rain, so that smoke, on the contrary, can be stamped as a purifier of the atmos-

phere and a benefactor of the human race." He believes that we can safely depend on our instinct, and this tells us decidedly that smoke does not agree with us.

125. Atmospheric pollution. Hemeon, W. C. L. and Hatch, T. F. Ind. Eng. Chem. 39: 568, 1947. (May)

"Rarely do the ascertainable facts establish that common atmospheric pollutants are hazardous to health in the sense that demonstrable ill health results from inhaling polluted air." Sulfur dioxide is one of the chief contaminants, and it is best to operate plants so that the concentrations are not in excess of 0.5-0.75 parts per million. A table is given with a "general classification of pollutants, according to outstanding physical properties."

126. The effect of atmospheric smoke pollution. Summary of opinions from current literature. Langsdorf, A. S. Mech. Eng. 49: 1213, 1927.

The theme of the paper is that atmospheric pollution constitutes not only a nuisance but also a source of danger to numerous living organisms, including human beings, and is a serious menace to the permanence of a great variety of materials. The difficulty in raising public opinion to action in smoke abatement is cited.

1. Physical and chemical deterioration caused by smoke necessitates an extra cost of cleaning and washing materials, such as clothes, carpets, paintings, and walls of buildings, soiled by soot and tar; and an increased need for artificial lighting. The smoke's corrosive action in metals is also costly.

2. Damage to vegetation is caused by the clogging of pores and the destructive action of sulfuric acid, now considered, by far, the principal cause of damage. The sulfuric acid in sootfall acidifies the soil and renders it nonproductive for many types of vegetation.

3. Seriousness of the effect of sulfuric acid and estimates of the amount of sulfuric acid deposited annually in St. Louis are discussed.

4. The harmful effects of smoke on health have not been proved on a clear, scientific basis. The statistics reported by various authors showing a correlation of smoky days with increasing incidence of respiratory disease and deaths are not considered to be scientific proof of cause and effect.

5. Smoke and pneumonia: Smoke is considered of minor importance but nonetheless a factor in the incidence of pneumonia. However, the author cites W. B. Smith, who relates the consequences of a series of dense smogs in Glasgow in 1909 in comparison with contemporaneous conditions in seven neighboring towns. The other towns were not nearly as smoky and the death rate following

each smog in Glasgow was as much as twice the rate of the other seven towns.

- 127. Health aspects of air pollution.** Lanza, A. J. Published by Smoke Prevention Association of America, Chicago, Ill., May 24, 1949.

This is a generalized consideration of air pollution of the community and its health aspects. Some of the sources of air pollution are discussed, and it is stressed that industrial stacks are not the only, and not even the main, source of air pollution, the chief contributors being autos, homes, and office buildings. It is concluded that common industrial poisons do not affect the general population through atmospheric pollution. The Donora and Meuse Valley incidents are cited as rare combinations of circumstances. The nuisance factor of air pollution, such as local mucous membrane irritation and extra filth, is mentioned. Examples are cited of the irresponsible opinions and papers injudiciously and unfairly written condemning air pollution for effects which have not been proved.

- 128. The present position of the hygiene of the atmosphere.** Liesegang, W. *Klin. Wchnschr.* 1: 463, 1928. (Abstr. C. A. 23: 4003, 1929) (Aug.)

"The use of tar is advocated for keeping dust down on the street. There is no definite proof that smoke has any influence on health. Carbon monoxide in amounts present in Berlin has a pronounced effect on the health of city dwellers."

- 129. Smoke and soot; its effect on health.** Mehl, W. *Gesundheit (Leipzig)* 30: 747, 1905. (Abstr. Mellon Inst. Smoke Invest. Bull. No. 9, 1914)

In this paper the author concludes that "no one has yet shown that smoke and fog are injurious to health." He later proceeds to demonstrate by means of statistics that the increased death rate from respiratory diseases in large industrial centers must be related to the influence of smoke and dust.

- 130. On smoke.** Metcalf, W. *Proc. Engin. Soc. West. Penn.* 8: 23, 1892.

The view is presented that smoke is not injurious to health and that smoke prevention in an iron manufacturing region is impracticable. In order to have a smokeless sky, the iron must be oxidized and will therefore be literally burned up. This is too costly. Coke produces more toxic gases than does smoke.

DISCUSSION of INDIVIDUAL SUBSTANCES

Sulfur Dioxide

- 131. The effect of sulfur dioxide on man.** Anonymous. Bureau of Mines Bull. 98: 36, 1915.

Describes an experiment on 60 persons to determine what concentration of sulfur dioxide creates a nuisance. It is concluded that the average person is conscious of sulfur dioxide pollution at a concentration 3.5 parts per million but that "trained" persons are conscious of such pollution at 2.5 parts per million. Thus, sulfur dioxide is a nuisance to a community when its concentration is 3 parts per million or more. No mention is made of harmful concentrations and their effects.

- 132. Effects of the various refrigerants (including sulphur dioxide) upon the human body.** Anonymous. Refrig. Eng. 9: 141, 1922.

Because of the marked irritating effect of sulfur dioxide on the eyes and throat, the resulting desire to get fresh air is considered by the author to decrease the possibility of harm from this gas. Those exposed to 5 to 20 parts per million are so uncomfortable that they are compelled to leave the area of concentrations. However, small amounts of sulfur dioxide may cause coughing, and those unaccustomed to it cannot tolerate it. Those who are exposed to it in their daily work establish a gradual tolerance and take no notice whatsoever of an atmosphere in which it is present to such an extent that persons unaccustomed to it cannot breathe it.

- 133. Toxic possibilities of sulphur purification.** Anonymous. J. A. M. A. 119: 854, 1942. (July) (Abstr. J. Indust. Hyg. & Toxicol. 25: 12, 1943)

Sulfur dioxide is primarily a respiratory irritant, and as little as 0.001 percent may produce coughing. Slightly higher concentrations may produce conjunctivitis, pharyngitis, and bronchitis. The tolerable limit of sulfur dioxide concentration is 10 parts per million.

- 134. Maximum permissible concentrations of atmospheric contaminants.** Anonymous. Industrial Hygiene Manual, A.S.C. Patterson Field, Fairfield, Ohio, 1943. (Dec.)

The concentrations listed are those recommended by various state industrial hygiene units. Sulfur dioxide is listed at 10 parts per million and hydrogen fluoride at 3 parts per million.

135. Conditions of library atmospheres. Anonymous. Atmos. Poll. Bull. 16: No. 1, 1948.

Sulfur dioxide in London air never exceeds 1 part per million. Leather-bound library books reduce the concentration in libraries, particularly in still air, because the vegetable-tanned leather rapidly absorbs sulfur dioxide from the atmosphere. The amount of absorption by the books can be determined, as can the state of deterioration from the action of the sulfur dioxide, so that variations will represent degree of exposure over a long period. The concentration of sulfur dioxide present will be determined by the type of ventilation in the library as well as by the concentration of sulfur dioxide in the outside air.

136. Sulfur dioxide in air of industrial community. Betz, C. E., Holden, J. H. and Handy, J. O. Ind. Eng. Chem. 25: 774, 1933. (July)

Results are given, in summary, of daily sulfur dioxide determination in Pittsburgh, Pennsylvania, on the roof of the laboratory. Concentrations for the year varied from 0 to 2.5 parts per million. The highest concentration appeared in morning hours.

137. Asthma in children; its cause and treatment. Cooke, R. A. J. A. M. A. 102: 664, 1934. (March)

This review of asthma has particular reference to the disease in children. Discussing nonspecific causes, the author considers exercise, eating, heat, humidity, and extreme cold not to be fundamental causes, but rather excitatory, precipitating an attack in an individual with an asthmatic predisposition or an asthmatic history. On clinical grounds, he believes that sulfur dioxide may be a specific precipitating cause of asthma.

138. Asthma following prolonged exposure to sulfur dioxide; report of a case. Dowling, H. F. M. Ann., District of Columbia 6: 229, 1937. (Oct.) (Abstr. J. Indust. Hyg. & Toxicol. 20: 44, 1938) (Feb.)

A case report of a refrigerator repairman who, in the course of his work, was exposed to sulfur dioxide. He had suffered asthma as a child but had had no clinical symptoms for 17 years. The disease was reactivated by exposure to the irritating gas and progressed to asthmatic bronchitis.

139. Smoke prevention. Evans, W. A. Illinois State Geol. Survey Bull. 14: 333, 1909.

"In 1907, Chicago had 32,000 deaths. Of these, 9,000 were due to what we termed bad-air diseases: consumption, pneumonia, bronchitis and influenza." Of these, 4,900 were due to pneumonia, 3,700 to tuberculosis, 500 to diphtheria, and 376 to typhoid. In 1908, some

improvement in "impure air diseases" was made by the air pollution control activity by the Smoke Commissioner and the Health Department, as well as by industry. The author states that the carbon in the air resulting from improper combustion is practically harmless but that the sulfur dioxide is believed to be harmful.

140. **Poisonous gases encountered by firemen.** Fieldner, A. C.; Katz, S. H.; and Kinney, S. P. U. S. Bur. of Mines, Tech. Paper 248, 1921.

Smoke is extremely irritating to the eyes and throat and may interfere with breathing sufficiently to produce unconsciousness. When inhalation of sulfur dioxide is prolonged, or the concentration is very high, death may result from respiratory spasms and asphyxia. "Ordinarily, however, exposure to mild fumes merely produces headache, coughing, smarting of the eyes, and later constriction of the chest and bronchitis." The effects of other gases, such as carbon dioxide, carbon monoxide, ammonia, illuminating gas, and chlorine, are also discussed.

141. **Experimental contribution to the chemico-toxicological investigation of sulfur dioxide.** Gerin, C. Arch. Antropol. crim. 54: 413, 1934.

This paper on in vitro and in vivo studies to determine methods for finding evidence of sulfur dioxide poisoning at necropsy discusses the various methods for testing for sulfur dioxide in vitro and the changes that sulfur dioxide may undergo. Sulfur dioxide, for example, may form sulfuric acid, or it may combine with hydrogen sulfide to form free sulfur or water. Hydrogen sulfide is apparently formed as a product of putrefaction after death. Since sulfur dioxide is a gas, it is readily eliminated from the body. It changes to sulfuric acid in contact with the oxygen of the blood and the moisture of the skin membrane.

The problem then was to determine actual sulfur dioxide poisoning and eliminate the possibility of getting positive results due to release of sulfur from protein breakdown or poisoning due to sulfuric acid or hydrogen sulfide. Since there is also a danger in confusing hydrogen sulfide and sulfur dioxide, the author removed hydrogen sulfide with lead acetate. Alkaline carbonate is added to transform organic compounds of sulfur dioxide into soluble alkaline sulfites. For positive results, immediate post mortem study is required in chronic poisoning. In acute poisoning the investigation is positive only if made within 48 hours after the death.

142. **Sulfur dioxide chemical pneumonia; report of a case.** Goldburgh, H. L., and Gouley, B. A. Ann. Int. Med. 18: 237, 1943. (Feb.)

The danger of exposure to sulfur dioxide in the refrigeration industries is cited as an example of the increasing exposure of workers to various noxious gases. The authors seek to exemplify in this report (1) the rapid destructive effect of concentrated sulfur dioxide inhalation and (2) the apparently beneficial results of sulfonamide therapy in such cases.

The action of sulfur dioxide is similar to nitrogen dioxide, which is corrosive to the moist mucous membranes. The greatest damage is in the bronchi and bronchioles with erosion of the lining epithelium, deciliation, edema of the underlying submucosa, spasm of the bronchial muscle, and thrombosis of the small arteries and veins. With inhalation of concentrated fumes, the acute process extends into the alveolar ducts and the alveoli. In the alveoli the inflammatory exudate consists of fibrin and plugs of desquamated cells resembling a picture of the so-called lobular catarrhal pneumonia. During recovery, regeneration takes place with difficulty with the possibility of the development of bacterial infiltration and possibly the development of bronchiectasis, bronchial asthma, and chronic bronchitis. It is doubted that recovery is ever complete following acute sulfur dioxide inhalation.

In the case cited, a boy, age 15, previously well, was exposed to a high concentration of sulfur dioxide. Acute evidence of bronchopulmonary involvement was quickly presented. Cyanosis and dyspnea were present. Sulfathiazole is given large credit in recovery, but it did not prevent the development of bronchiectasis.

143. **A Manual of Practical Hygiene, 5th ed.** Harrington, C. Lea & Febiger, Philadelphia, 1914.

"The weight of evidence concerning the relation of this gas (sulfur dioxide) to health indicates that its effects are neither serious nor lasting, and are exerted *more on the digestive than on the respiratory* function. In some individuals, a small amount in the atmosphere causes *epigastric* pain and *heart burn* very quickly."

144. **Forest devastation by smoke.** Horicht, W. *Kranke Pflanze* 15: 90, 1938. (Abstr. C. A. 32: 7075, 1938) (Sept.)

Sulfur dioxide is the chief offender of smoke against vegetation. The picture of sulfur dioxide poisoning comprises red spots on the leaves, reddening of the needle termini, and lowered respiration. The deposition of soot, while not poisonous, interferes with respiration and excludes light.

145. **On the question of effects of chronic exposure to sulfur dioxide gases. Results of an investigation among workers in an electron foundry.** Humperdinck, E. K. *Arch. Gewerbepath. Gewerbehyg.* 10: 4, 1940.

This is a report comprising the results obtained in examining 87 workers known to have chronic exposure to varying concentrations of sulfur dioxide gas (0.06 mg./liter to 0.4 mg./liter).

The most common finding was chronic catarrh of the upper air passages and bronchi. Rales were commonly heard in the chest. X-ray studies revealed evidence of emphysema. Histories revealed no unusual incidence of pneumonia. The posterior pharyngeal wall was frequently reddened and covered with mucous threads. More pronounced acute symptoms appeared in the newer workers.

Red blood cell counts and hemoglobin values were elevated. The white blood cell count did not show any essential changes.

146. On the effects of prolonged exposure to sulfur dioxide. Kehoe, R. A., Machle, W. F., Kitzmiller, K. and LeBlanc, T. J. J. Indust. Hyg. 14: 159, 1932. (May)

The purpose of this study was to substantiate or repudiate the claims made about exposure to sulfur dioxide. These ranged from marked toxicity to the belief that exposure is beneficial to health. The study involved workers at an electric refrigerator manufacturing plant, where there were ideal conditions of known exposure in some workers and nonexposure in others doing comparable tasks. One hundred exposed and one hundred nonexposed workers were chosen for complete histories and physical examinations. The control group closely approximated the exposed group as to age, weight, height, blood pressure, erythrocyte count, hemoglobin percentage, and white blood cell count. They differed in that the polymorphonuclear counts were higher in the control group and the lymphocytes were higher in exposed group. The differences were statistically significant. Physical finding differences statistically significant are tabulated and include slight and chronic pharyngitis, urine acid to methyl red, slight chronic tonsillitis, and abnormal reflexes. Acclimatization is also discussed. Chest X-ray studies also revealed statistically significant differences. Symptomatology was principally confined to the respiratory tract except that statistically significant differences were noted for shortness of breath on exertion, increased fatigability, altered sense of taste or smell, and increased sensitivity to other irritants.

147. Pure air for our cities. Keyes, D. B. Scientific Monthly 35: 427, 1932.

A discussion is presented to the effect that sulfur of coal produces sulfur dioxide and that this in turn produces sulfur trioxide, which with water forms sulfuric acid. It is the sulfuric acid which the author believes causes the injurious effects on people. Ways and

means of eliminating sulfur dioxide from the flue gas and coal before burning were devised and are discussed in detail.

- 148. Acute poisoning by suffocating gas (sulfur dioxide).** Martini, T.; Dossola, A. and Celener, D. *Semana méd.* 47: 110, 1940.

A clinical case of a fatality following inhalation of sulfur dioxide is discussed. The patient was carrying a small tank of sulfur dioxide which burst, and he was admitted to the hospital the following day. Immediate symptoms were nausea, vomiting, hypothermia, retrosternal and epigastric burning, and irritation of upper air passages. Examination on the following morning revealed: axillary temperature 38.50 C.; pulse 130, slight cyanosis, hoarseness, seropurulent coryza, bilateral rhonchi, subcrepitant rales, and some sibilant rales. Later these were signs of pulmonary edema and diffuse bronchitis, temperature 39° C.; and intense dyspnea, pulse 130, B. P. = 110/60. The nervous system was normal. After three days there was a decrease in temperature and an improvement in the general condition, which was maintained for one week. Then the temperature rose again with exacerbation of the dyspnea and with many coarse and moderate subcrepitant rales. The pulse was 120. Icterus then appeared with tenderness over liver. The electrocardiograph next revealed auricular flutter with ventricular rhythm of 140. Approximately two months later he died suddenly. No autopsy was performed.

- 149. City air searched for sulfur fumes.** McMahon, J. F. *Science* 89: 61, 1939.

A 15-month survey was conducted to determine average amounts of sulfur gases in the air over 25 American cities. Five metropolitan districts received more extensive study. Measurements were taken at all hours of the day and night and during all seasons of the year. Results varied from a high of 0.128 parts per million in St. Louis to 0.009 parts per million in Washington, D. C. It was concluded the amounts (even the maximum reading 2.266 parts per million found in St. Louis) were insufficient to cause harmful physiological effects. Home fires using high sulfur content coal, which produced sulfur gases, were found to be big contributors to the pollution. Concentrations were higher in the cold seasons or "heating seasons." A close relationship existed between wind velocity and pollution, the highest concentration being found on foggy nights.

- 150. Solution of the problem of the smoke nuisance.** Mehrstens, J. H. *Glaser's Annalen für Gewerbe u. Bauwesen* 60: 1907. (Abstr. Mellon Inst. Smoke Invest. Bull. No. 9).

A general resume of the effects of various constituents of smoke upon health:

"It is not the dust only that is injurious, but it is the invisible products of combustion escaping from the chimney in the form of gases, of which we need to take into consideration only carbonic acid, nitrogen, carbon dioxide, carbon monoxide, sulfur trioxide, sulfur dioxide and sulfurous acid and other heavy gases. Carbonic acid and nitrogen can probably be regarded as injurious only when they are driven directly into dwellings, and this cannot happen unless the chimneys are not high enough. The carbonic acid, which is extremely poisonous, is usually present in such slight quantities that it becomes greatly diffused as soon as it escapes from the chimney. On account of its lightness, it also arises rapidly and is lost in the higher strata of air; but, on the other hand, the gaseous sulfuric acid (sulfur dioxide) which is considerably heavier than air, is such an injurious gas that first of all our efforts must be directed toward preventing it from doing harm, all the more as it is not only the human organism that is injured but also, in a positively destructive manner, the vegetation, soil, and buildings. Those facts show that any smokeless furnace with a direct combustion has little value for the public as far as the purification of the air is concerned unless the dust and the sulfurous acid are retained at the same time."

- 151. Damage to greenhouse plants caused by town fogs with special reference to sulfur dioxide and light.** Metcalfe, W. *Ann. Applied Biol.* 28: 301, 1941. (Nov.)

Experiments were done with sulfur dioxide and similar atmospheric contaminants. It was found that "plants will endure higher concentrations of sulfur dioxide in a relatively dry, than they will in a humid, atmosphere." Effects of sulfur dioxide on plants and effective measures of protection are discussed.

- 152. Air pollution and the weather.** Morris, D. R. *Refrig. Eng.* 38: 83, 1939. (Abstr. C. A. 33: 9479, 1939) (Nov.)

Air pollution results principally from the burning of coal from which noxious gases and solid particles escape into the air. "It is estimated that in a single Chicago plant 500 tons of sulfur as sulfuric acid escape into the atmosphere every 24 hours." Five percent of the coal goes into the air as unburned carbon. Wind velocity and direction determine the rate and region in which smoke is dispelled.

- 153. Morphologic and biochemical changes in the blood in acute sulphur dioxide poisoning.** Nikulina, M. M.; Hetmann, A.; and Morgalina, N. M. *Leningrad Inst. for investig. Indust. Dis.* 8: 89, 1934. (Abstr. J. Indust. Hyg. & Toxicol. 17: 52, 1935) (May)

The morphology of the blood is not changed in sulfur dioxide poisoning, but there is an increase of acid and of sugar in the blood, and this acidosis may be the chief cause of death. Administration of soda lessens the severity of the symptoms in animals and prolongs life.

154. Sulfur dioxide as a factor in the smoke problem of Salt Lake City. Perrott, G. St. J. U. S. Bur. Mines, Rep. Invest. No. 2128, 1920.

Extensive experiments have shown that concentrations of sulfur dioxide below 0.5 parts per million have no injurious effect on growing crops or vegetation. "For injury to result with this concentration, continuous exposure throughout the growing period would be needed together with a high relative humidity of 80 to 100 percent. A concentration of 3 parts per million is necessary before the average individual can detect its presence." So in order for sulfur dioxide to be an important constituent in air pollution, its concentration must be 0.5 or 1.0 parts per million.

In this study 332 determinations were made. The highest concentration (0.8 parts per million) was noted on a foggy, smoky day with little wind. A table lists the results of the above 332 determinations. Samples from the upper level of the atmosphere were obtained by airplane. The results show that no heavy blanket of sulfur dioxide of high concentration was hanging over the city at any level below 3,000 feet.

155. Industrial Poisoning from Fumes, Gases and Poisons of Manufacturing Processes. Rambousek, J. Arnold Press, London, 171, 1913.

"Sulphur dioxide is a colorless, pungently smelling gas which, acting in low concentration or for a short period, causes cough and irritation of the mucous membrane of the respiratory passages and of the eyes; acting for a longer period, it sets up inflammation of the mucous membrane, bronchial catarrh, expectoration of blood, and inflammation of the lungs . . . a proportion of 0.03 to 0.04 per 1000 of sulphur dioxide in the air has a serious effect on a person unaccustomed to it . . ."

156. Use of sulphur dioxide in the treatment of the epidemic cold. Rawlins, A. G. Arch. Otolaryng. 25: 119, 1937. (Feb.)

The study is limited to epidemic colds which pass through families and neighborhoods, as does measles, in contrast to flare-ups of sinusitis or streptococcus sore throat. The use of sulfur dioxide was prompted by success in destroying plant viruses with 0.6 to 1.5 percent sulfur dioxide.

Sulfur dioxide was administered by inhalation of sulfurous acid gas. Of 80 patients, 14 received no relief, and 66 stated they were completely cured on the 1st or 2nd day after therapy was started. These 66 patients stated that their colds usually lasted 1 to 2 weeks. Treatment in each case was given in the prodromal stage of the cold. The same therapy was tried after 3 or 4 days of onset with practically negative results. "It was found that in what was apparently an epidemic of colds, sulphur dioxide gas inhaled in the first 12 hours stopped the cold in 24 hours in a large percentage of the cases." The technic required getting the sulfur dioxide gas into the upper respiratory tract without getting appreciable amounts into the lungs. The possibility of decreased colds among workers exposed to sulfur dioxide is discussed. The author questioned a few workers and one plant manager in a plant where there was exposure to sulfur dioxide and found that colds were infrequent.

157. **The air of London.** Regan, C. J. J. Roy. Inst. Pub. Health Hyg. 9: 382, 1946.

A summary is presented of the work done in the past several years on the determination of the contents of the atmosphere over London.

158. **Sulfur dioxide in Pittsburgh air.** Schade, C. J. Indust. Hyg. & Toxicol. 15: 150, 1933. (May)

This paper presents the results of a series of sulfur dioxide determinations made of the air from 1927 to 1932 in Pittsburgh as a part of a broad air pollution investigation. Three sampling stations of three heights, 40 to 163 feet were used. It is reported that on days that the fog cleared by afternoon, there was a decrease of sulfur dioxide. On days that fog persisted, the sulfur dioxide concentrations were found increased. In all instances the levels of sulfur dioxide were low. The report concludes that the amount of sulfur dioxide present in Pittsburgh air is too small to be a cause of concern from a hygienic standpoint.

159. **Results of research on air pollution by sulfur dioxide in region of zinc industries in Silesia.** Seczyk, K. Medycyna Doswiadczalna i Spoleczna 15 (3-4): 296, 1932.

Gases emanating from zinc and lead foundries in the district of Katowice have been detrimental to the small nearby farms. These foundry gases are composed of particles of ore, coal dust, lead, zinc, sulfur dioxide, carbon dioxide, carbon monoxide, and possibly hydrogen sulfide and arsine. Because there is a limited demand for sulfuric acid, sulfur dioxide is discharged into the air.

Toxic effects of sulfur dioxide on man are described. Low concentrations cause "coughing and symptoms of scratchy mucous mem-

branes of the respiratory passages. High concentrations damage mucous membranes and cause catarrh of bronchi, possibly hemorrhage, and finally inflammation of the lungs." There is apparently no effect on the blood. A permanent worker is not affected in a sulfur dioxide atmosphere, whereas a new man may feel ill.

Study was undertaken "to determine how sulfur dioxide is diluted in the atmosphere, and at what radius from the center of production it settles and can act injuriously on people." The manner of carrying out research is described. It was found that a wind of uniform velocity (2 meters/sec.) does not appreciably dilute the sulfur dioxide.

Data are given for many sampling points: distance from the source of sulfur dioxide, concentration of sulfur dioxide, temperature, humidity, wind direction, and concentration of sulfur dioxide found at that point. Rain never favored the disposal of the gases because the concentration was higher in rain than during good weather.

The levels of sulfur dioxide obtained for Silesia were more damaging than those for Pittsburgh.

In fine weather, the sulfur dioxide content for the locality immediately about these foundries was lower than when there was a heavy fog, a low overcast, or rain. The wind played an important role in the distribution of the gases. Weak winds and calms appeared to disperse the gases much better than strong winds. Sulfur trioxide, hydrogen sulfide, and hydrogen fluoride were found in the chimney gases, but not in toxic amounts.

160. Effects of sulfur dioxide on plants and animals. Setterstrom, C. Ind. Eng. Chem. 32: 473, 1940. (April)

In cases where only 0.1 to 0.2 parts per million sulfur dioxide were used on experimental animals, nothing injurious happened because the sulfur deficiencies of nutrient supplies were augmented by the atmospheric sulfur dioxide. Factors influencing the effect of sulfur dioxide on plants are: (1) Resistance was greater at 40° F. or below; (2) resistance decreased with increases in relative humidity; (3) ample water supply made them more susceptible; and (4) younger plants were more resistant than older ones. The studies of effects on animals of prolonged exposures to sulfur dioxide are reviewed.

161. Atmospheric pollution due to gas. Stern, A. C. Heating and Ventilating 42: 73, 1945. (Feb.)

Flue gas is discussed as the principal source of gaseous air pollution in cities. The principal contaminant of flue gas is carbon dioxide, of which the maximum concentration found in cities is 0.04 percent with no known deleterious or objectionable effect upon

either plant, animal or human life. Most flues also contain carbon monoxide along with the carbon dioxide, and "carbon monoxide concentrations such as exist in even highly polluted atmospheres are not known to adversely affect either plant life, materials, or structures." Other studies have shown that traffic policemen are unharmed by carbon monoxide exposure. Carbon monoxide therefore presents no problem as an atmospheric hazard.

"Although concentration of sulfur dioxide in air over 1 part per million will mark or kill vegetation, those below 0.2 parts per million cause no known damage to plant life." The generally accepted maximum allowable concentration of sulfur dioxide for human exposure is 10 parts per million, which is considerably higher than any atmospheric concentration yet recorded other than in the direct wake of gases from a particular stack. It is conjectured that a concentration of 40 parts per million was reached in the 1930 Meuse Valley disaster.

162. Atmospheric pollution due to smoke. Stern, A. C. Heating and Ventilating 42: 67, 1945. (May)

"A droplet of sulfuric acid, the form in which sulfur trioxide would exist in a mist, will be stable at a lower relative humidity than a droplet of water. Therefore, once a fog is formed in an atmosphere containing sulfur dioxide, it will tend to be a more persistent fog than one in an unpolluted atmosphere. It will be a more objectionable one because of its corrosive and irritant character."

The report of the Committee on Public Health Relations of the New York Academy of Medicine is cited: "Inhalation of carbon particles and irritating fumes lower the resistance of the nasal mucous membrane, rendering it susceptible to acute and chronic infections which may involve the ear. Enlargement of the tonsils and redness and congestion of the pharynx and larynx have also been ascribed to atmospheric pollution. Smoke likewise irritates the membranes of the entire respiratory tract, predisposing to pneumonia and emphysema. Smoke diminishes the potential reserve, working capacity, and well-being of the individual and increases fatigue and irritability, whereas sunshine exerts an exuberant influence."

163. Effects on animals of prolonged exposure to sulfur dioxide. Weedon, F. R.; Hartzell, A. and Setterstrom, C. Contrib. Boyce Thompson Inst. 10: 281, 1939. (April-June) (Abstr. J. Indust. Hyg. & Toxicol. 23: 53, 1941) (March)

Effects on animals of exposure to sulfur dioxide include general visceral congestion, edema of the lungs, at higher concentration, acute dilatation of the right heart, gross distention of the stomach

with multiple ulcers and hemorrhages at the higher concentration, and distention of the gall bladder.

- 164. Toxicity of ammonia, chlorine, hydrocyanic acid, hydrogen sulfide, sulfur dioxide. V. Animals.** Weedon, F. R.; Hartzell, A.; Setterstrom, C. *Contrib. Boyce Thompson Inst.* 11: 325, 1940. (Oct.-Dec.) (Abstr. *J. Indust. Hyg. & Toxicol.* 23: 52, 1941) (March)

Houseflies, mice, and rats were exposed to a continuous flow of ammonia, chlorine, hydrocyanic acid, hydrogen sulfide, and sulfur dioxide gases under controlled conditions at concentrations of 16, 63, 250, and 1000 parts per million for periods up to 16 hours. Toxicity curves are presented at various concentrations of the gases. The order of decreasing toxicity for these gases was found to be hydrocyanic acid, hydrogen sulfide, chlorine, sulfur dioxide, and ammonia. With sulfur dioxide, the signs qualitatively resembled those of chlorine. The rats showed edema and hemorrhage in the lungs. Dilatation of the heart and moderate dilatation of the stomach without ulcers also occurred in the rats exposed to sulfur dioxide.

- 165. Experimental acute gastric ulcers produced in animals by exposure to sulfur dioxide gas.** Weedon, F. R. *New York State J. Med.* 42: 620-3, 1942. (Abstr. *C. A.* 36: 4906) (Aug.)

"The occurrence and nature of gastric ulcers in guinea pigs and mice exposed to sulfur dioxide at levels of 10, 25, 35, 65, 100, 150, 300, and 1000 parts per million are described. No effects on the stomach were observed below 65 parts per million. At 65 parts per million one-third of the animals showed acute distention of the stomach on the ninth day, and at 100 parts per million half the animals showed distention on the fourth day, while two gastric perforations occurred. At 300 parts per million most of the animals showed distention and multiple hemorrhagic ulcers on the third day. Perforations were frequent. At 1000 parts per million the ulcers were less frequent and of small size, but the life span was shorter. The gross and microscopic appearance of the lesions is described."

- 166. The effect of the inhalation of gases.** Welsh, G. A. *J. Indust. Hyg.* 2: 328, 1921.

Sulfuric acid mist irritates the exposed mucous membranes as well as the thin epidermis on the face and back of hands. A person gassed by an irritating gas complains of difficulty of inspiration, shallow inspiration with coughing spells, exertional dyspnea, palpitation, dryness and burning of the throat, throbbing at the temples, and nausea and vomiting.

Carbon Monoxide

- 167. Bus fumes acquitted: New York Transit Commission finds no dangerous concentration of carbon monoxide. Anonymous. Transit J. 80: 441, 1936. (Nov.)**

Although there is a widespread belief that dangerous concentrations of carbon monoxide are often present in buses and on the streets where they operate, this idea is erroneous, according to the findings of the engineering department of the New York Transit Commission. In all the time buses have been running, no case fatality has been reported as due to carbon monoxide. The offensive aldehydes give rise to complaints of bus fumes. The highest concentration of carbon monoxide found on a bus was 2 parts per 10,000, and this was found while the bus was standing.

- 168. Carbon monoxide poisoning and the automobile exhaust. From the review of literature by the Special Sub-committee of the Committee on Public Health Relations. Bull. New York Acad. Med. 2: 402, 1926. (Aug.)**

Carbon monoxide poisoning is closely related to the history of mankind. Carbon monoxide is so dangerous because it is colorless, tasteless, and practically odorless. The weight of opinion favors carbon monoxide as causing anoxemia, which, in turn, causes death. Clinical symptoms, both acute and chronic, are reviewed. The individual's idiosyncrasy will determine whether he will receive permanent damage from carbon monoxide or none at all. Tolerance or immunity to carbon monoxide will protect some from large amounts of the gas, and yet others will be overcome by the same amount of carbon monoxide gas.

Effects of the gas have been noted by traffic officers on busy Chicago street corners. All writers appear to agree that slow, gradual gassing is far more serious to a man than to be suddenly exposed to a high concentration. In gasoline engines there will be from 2-13 percent, or even higher, of carbon monoxide in the exhaust. Carbon monoxide density is practically the same as air density. The composition of exhaust gas is tabulated. Carbon monoxide from car exhaust lies in a layer about 5 to 15 feet above the street, and the concentration depends upon atmospheric conditions. On damp, still days the carbon monoxide content of the street mounts during heavy traffic to a point where a distinct health menace is created. Some writers accredit some accidents to the mental dullness of drivers due to carbon monoxide. Headache, dizziness and reduced vision and coordination are common complaints of motorists in a slow moving line of traffic. Traffic police report fatigue, dryness in the

throat, headaches and bronchial irritation after directing traffic at a busy intersection.

- 169. The problem of exhaust gas in streets and repair shops of large cities.** Bloomfield, J. J. and Isbell, H. S. *Pub. Health Rep.* 43: 750, 1928.

An exhaustive technical study of the concentrations of carbon monoxide gas at busy intersections, auto repair shops, and in buses in fourteen large United States cities, is reported. Street samples, taken under the worst possible conditions in regard to carbon monoxide content, showed 1-2 parts per million. Repair shops showed from 100 to 1,000 parts per million.

It is concluded that concentrations encountered on streets are not hazardous. The same conclusion is drawn for buses except where an exhaust leak may occur. It was suggested that policemen stationed at busy intersections may be subjected to toxic doses over and eight-hour day for a cumulative effect. A real hazard apparently exists in repair shops, even when ventilated, as concentrations frequently exceed allowable maximums. The only adequate remedy appeared to be venting the exhaust by a hose attached to the tail pipe, and restricting motor operation to 30 minutes.

- 170. Respiratory hazards incident to fire and explosions under combat conditions in naval vessels.** Brown, E. W. and Bosman, J. *BUMED News Letter*, Wash. 6: 1, 1945.

Types of fires are classified as to material burned. The chief hazards are anoxia, caused by carbon monoxide, nitrous fumes and the carbon particles, with resultant death, and injury from blast, heat or direct flame. The use of a gas canister is discussed as well as treatment of smoke casualties. The treatment centers around maintaining adequate respiration, with all means at hand.

- 171. The smoke of Paris; the influence of the products of combustion on the urban atmosphere.** Gautier, A. *Rev. d'hyg.* 23: 97, 1901. (Abstr. Mellon Inst. Smoke Invest. Bull. No. 9, 1914)

The author made an analysis of air taken from the open street and found only one part in 500,000 of carbon monoxide, a proportion presumably inert in regard to health. He believed, however, that the air near factories would contain a sufficient amount of this gas to prove a menace to health.

- 172. Physiological chemical effect of exhaust gases.** Kraut, H. *Chem. Zentr.* 1: 1570, 1941. (Abstr. *J. Indust. Hyg. & Toxicol.* 25: 175, 1943) (Oct.)

The physiological effect of motor exhaust gases is due primarily to the carbon monoxide content. The exhaust gases from diesel

motors, in some cases, cause symptoms of acute irritation because of the sulfur dioxide content.

- 173. Histological reactions of the lungs after inhalation of certain anesthetics and toxic gases.** Mosinger, M. and Rochette J. *Ann. de méd. lég.* 19: 600, 1939. *Zentrbl. f. Gewerbehyg.* 27: 227, 1940. (Abstr. C. A. 36: 3547, 1942) (June)

"Guinea pigs were subjected for varying periods of time to the inhalation of ethylene oxide and chloride, and carbon monoxide and to the action of cold (3 to 4° F.). Circumscribed areas of emphysema and atelectasis were more pronounced after long inhalation of ethylene oxide than with the other gases studied. Necrosis of the bronchial epithelium occurred only after chloride inhalation. Vasodilatation was also present. Inter-alveolar edema was also slight after inhalation of ethylene oxide and carbon monoxide, very severe after chloride inhalation and pronounced after exposure to cold. Peribronchial edema occurred only after chloride inhalation. Alveolar edema appeared early after inhalation of chloride and carbon monoxide and late after ethylene oxide inhalation. Hemorrhagic symptoms appeared early and were pronounced after inhalation of chloride and carbon monoxide but were not otherwise observed. The appearance of mitoses in the alveolar epithelium and capillary epithelium were found only after the inhalation of ethylene oxide. The desquamation of the alveolar epithelium, which has been considered characteristic for war gases and anesthetics, was noted also after the action of carbon monoxide . . . it is therefore not characteristic, at least in the guinea pig . . ."

- 174. Carbon monoxide poisoning.** Noro, L. *Nord. med.* 20: 771, 1945. (Abstr. *Atmos. Poll. Bull.* 14: 16, 1946) (Nov.)

The author describes the clinical picture and pathogenesis of carbon monoxide poisoning and the existence of the poisoning in drivers of motor cars operated by charcoal gas in Finland. Of the 5,000 drivers, who were questioned, symptoms of carbon monoxide poisoning were found in 67.5 percent of the cases. The symptoms of acute poisoning were complained of by 3,069; symptoms of chronic poisoning, by 2,506 drivers. In 530 cases the poisoning had caused inability to work. In Finland at present, carbon monoxide poisoning is the most common occupational disease.

- 175. Carbon monoxide in patients with carcinomas.** Roffo, A. E. Jr. *Bol. Inst. de Med. Exper. para el Estud. y trat. d. Cancer* 18: 559, 1941. (Abstr. C. A. 36: 2910, 1942) (May)

Spectrographic examination for the carbon monoxide content of blood in carcinomatous patients revealed that the carbon monoxide content was particularly high in persons exposed to two sources:

tobacco smoke and city air. Exposure to only one of the sources resulted in a lower carbon monoxide content. Although the carbon monoxide quantities thus determined were far below the toxic dose, the slow and chronic asphyxia created by it is of significant importance since it may well prepare the ground for carcinogenesis and also enhance the growth of already existing carcinomas.

- 176. Effect of exposure to known concentrations of carbon monoxide.** Sievers, R. F., Edwards, T. I., Murray, A. L. and Schrenk, H. H. *J. A. M. A.* 118: 585, 1942. (Feb.)

This is a study of traffic officers stationed at the Holland Tunnel, between New York and New Jersey, for 13 years. The average daily carbon monoxide concentration was 70 parts per million.

Most of the officers were symptom-free, and when complaints were made, they tended to be nonspecific. Some had throbbing frontal headaches, some dizziness, anorexia, mild nausea and spots in front of their eyes.

From the data obtained, the authors felt safe in concluding that the hearts of these men had not been damaged by carbon monoxide in the tunnel. Several individual cases showed some changes, but these were not attributed to the carbon monoxide. Twelve percent of the group of 156 men had a fine tremor of the outstretched hand. No other neurologic changes were noted. A number had simple scleral injection due to dust. The remainder of the examination showed no unusual abnormalities.

It was found that the amount of hemoglobin combined with carbon monoxide was directly related to smoking habits. The average red blood cell count was 5.2 million cells.

It was concluded that the study did not reveal any evidence of injury to health attributable to carbon monoxide exposure at the levels encountered.

- 177. Joint committee on atmospheric pollution.** Silverman, A. *Heating, Piping Air Conditioning 1*: 604, 1929. (Nov.)

"In the matter of carbon monoxide pollution of the air, practically every city dweller suffers from some degree of chronic anemia from this cause." It is stated that it is rare to find a city dweller who does not have some degree of anemia.

- 178. Street risk of carbon monoxide poisoning.** Wilson, E. D.; Gates, I., Owen, H. R. and Dawson, W. T. *J. A. M. A.* 87:319, 1926. (July)

Policemen at heavily traveled intersections in Philadelphia, complained of symptoms of carbon monoxide poisoning, such as headache, slight nausea, and muscular weakness. Tests for carbon

monoxide-hemoglobin concentrations made of the officers stationed throughout the city, showed decidedly abnormally high levels.

It was concluded that "the existence of a definite street risk of repeated or chronic slight carbon monoxide anoxemia is confirmed. Confirmation of such a diagnosis should be sought for by testing the blood for carbon monoxide."

Fluorides

179. **Chronic fluorine in sheep and its effect on the teeth.** Boddie, G. F. *Proc. Nutrition Soc. (England and Scotland)* 3: 94-7, 1945. (Abstr. C. A. 40: 1587, 1946) (March)

Sheep in the immediate neighborhood of an aluminum factory developed fluorosis; 100 percent of the flock one-half mile away, 62 percent of those three-quarters mile away, and 46 percent of those one and one-quarter mile away. The teeth were mottled, wore poorly, and were subject to infection. The fluorine content of the teeth varied from 0.25 to 0.86 percent (normal 0.15-0.19 percent). The herbage in the nearest area contained 61 parts per million of fluorine; the next field 44 parts per million and the soil, 51 parts per million. Running water from a stream nearby contained 0.1 parts per million of fluorine.

180. **The pathological anatomy and pathogenesis of chronic fluorine poisoning of domestic animals.** Cohos. Berlin u. Munch. Tierarztl. Wchnschr. 1941 (Abstr. C. A. 36: 5259, 1942) (Sept.)

"Permanent teeth show hypoplasia of the enamel, defective and irregular calcification of dentine, hence early and irregular wear. The teeth show changes as in rickets, in adult animals as in osteomalacia. Fluorine interferes with the action of the phosphatases, which are necessary for calcification. There seem also to be an inactivation of ascorbic acid and a reduction of glycogen."

181. **The effect of inhalation of hydrogen fluoride. I. The response following exposure to high concentrations.** Machle, W.; Thamann, F.; Kitzmiller, K.; Cholak, J. *J. Indust. Hyg.* 16: 129, 1934. (March)

The experiment was performed using rabbits and guinea pigs, with apparatus in which the concentrations of hydrogen fluoride inhaled were known. There was wide range of time (5 minutes to 41 hours) and concentrations (8-.024 milligrams of hydrogen fluoride per liter).

Evidence of irritation of respiratory tract at all concentrations was a constant feature as also was a slowing of the respiratory rate. Increased exposure and concentration gave increased effect, includ-

ing corneal erosion, necrosis of turbinates and marked conjunctival and nasal discharges, indicating effect on exposed mucous membranes. When death occurred, it was usually due to bronchopneumonia.

The highest concentration tolerated by two men for more than one hour was 0.1 mg. per liter. At this concentration there was smarting of exposed skin, conjunctival and respiratory irritation, and a marked taste of the gas, which was described as flat and sour. Repeated low concentration exposure (.026 mg. per liter) failed to elicit any adjustment or habituation.

Pathologic findings of the experimental animals are described.

182. The effects of the inhalation of hydrogen fluoride. II. The response following exposure to low concentrations. Machle, W. and Kitzmiller, K. J. Indust. Hyg. 17: 223, 1935. (Sept.)

For this study a concentration of hydrogen fluoride was used which was above toxic levels but low enough to be relatively non-irritating and therefore a level at which chronic human exposure might occur. Higher concentrations are sufficiently irritating to discourage prolonged exposure.

Animals used were guinea pigs, rabbits and monkeys. In the exposed groups, significant pathological findings were limited to the lungs, liver, and kidneys. The guinea pigs showed organized pulmonary hemorrhages and moderate hepatic congestion. There were some atelectasis and degenerative changes, and hyperplasia of the bronchial epithelium. The liver demonstrated scattered focal necrosis with fatty degeneration in one guinea pig. The rabbits showed leukocytic infiltration in the lungs with or without edema. Two rabbits had acute lobar pneumonia with miliary abscesses. The liver showed slight fatty degeneration. Kidney damage was striking, consisting of extensive degeneration and necrosis of portions of the convoluted tubules accompanied by varying degrees of compression or dilatation and with fibrous degeneration in areas of the cortex. Glomeruli showed inflammation, degeneration, thickening, increased cellularity, and sclerosis. Monkey pathology was confined to the kidney with degeneration and inflammation changes similar to above.

183. The effects of the inhalation of hydrogen fluoride. III. Fluorine storage following exposure to sub-lethal concentrations. Machle, W. and Scott, E. W. J. Indust. Hyg. 17: 230, 1935. (Sept.)

Six normal rabbits were fed food with a natural fluoride content. The teeth were found to hold a higher concentration of fluorine

then the bones. However, the bones contained more than half the fluorine found in these rabbits.

Ten rabbits, divided into two groups, were given different exposures to hydrogen fluoride. The concentration of fluorine in the teeth and bones as well as in the lungs and brain was increased. There were also severe pathological changes in the parenchymatous organs, but no growth or nutritional retardation or physical changes in the bones were noted.

184. Effects of additive and atmosphere-derived fluorine in Tennessee soils and forage crops. MacIntire, W. H. and associates. Paper presented at the American Chemical Society Meeting, San Francisco, March 28-29, 1949.

Insecticide and fertilizer fluoride incorporations have been studied 20 years in Tennessee through lysimeter, greenhouse, and forage experiments. Inputs of fluorine through barium and calcium compounds (up to 6,000 lbs. of such per acre) were soil-retained almost entirely against 10 annual 51-inch rainfalls. Rainwater leachings from two moderately limestoned soils carried 0.3 to 1.5 pounds of fluorine per acre per annum from 300 pound incorporations of fluorine as cryolite, magnesium fluoride, sodium fluoride, a sodium silicofluoride and through rock phosphate, none of which caused increase of fluoride in lysimeter-grown soybeans. Per acre input of 100, 200, and 500 pounds of fluorine as calcium fluoride and potassium fluoride induced no increase in fluorine content of pot-grown ryegrass, red clover or alfalfa on two limestoned soils, or those slagged to furnish corresponding inputs of fluorine, whereas those fluorides did raise the fluorine content in like crops on the unlimed soils. Rainwater drainages from quenched calcium silicate slag incorporations showed fluorine concentration 4 times that attained by saturated solution of calcium fluoride in the laboratory. Superphosphate incorporations corresponding to 500 one-quarter-ton incorporations induced no increase in fluorine content of nine large successive crops. Normal fluorine content was shown by several crops grown on translocated Tennessee and Kentucky soils of high phosphate-fluorine content. A year's collection of 800 samples of forage on two University experimental farms within 5 miles of industrial operations showed fluorine content of 50-75 parts per million in 40 percent of samplings, beyond 75 parts per million in 32 percent of samplings; many incidences beyond 100 parts per million and none less than 10 parts per million for operation "P" and for operation "A" 65 percent of samples showed 10-25 parts per million of fluorine, with many samples showing well above that range. Corresponding forage from control areas showed less than

8 parts per million of fluorine in 86 percent of cases and less than 5 parts per million in 76 percent of cases. Higher incidence of fluorine was found in rainwater at both locations.

Apparently, an abnormal incidence of fluorine in forage crops is not induced either through fluorides native to the soil or through rational incorporations of any solid fluorine material in similar soils of reasonable calcium content, or those adequately limed. Hence, toxic levels of fluorine in forage are deemed attributable to direct contamination from the atmosphere.

- 185. Chronic fluorine poisoning in cattle.** Meyn, A. and Viehl, K. *Arch. Wiss. Prokt. Tierheilk* 76: 329, 1941. (Abstr. C. A. 36: 5259, 1942) (Sept.)

"On a farm exposed to factory fumes containing fluorine, many of the cattle were poisoned. A slowly developing cachexia, muscular pains, considerable drop in milk production, striking dark pigmentation of teeth and accelerated wear of the incisor teeth were observed. The bones contained 7 to 10 times the normal amount of fluorine (up to 5.53 instead of 0.5 milligrams per gram of fat-free dry bone substance), less being found in teeth than in bones. Various plants grown on the farm (hay, cabbage) showed an increased fluorine content (6 to 21 milligrams per 100 gram air-dried material instead of 0.02 to 0.4 milligrams). The intoxication was attributed to the intake of food with this increased fluorine content."

- 186. Fluorine poisoning as a result of atmospheric pollution by a superphosphate works.** Schuursma, M. J. N. *Chem. Weekblad*. 38: 583, 1941.

Careful investigation showed that the dissemination of small amounts of fluorine by factories injured the health of nearby grazing cattle and lowered the milk production. Water samples obtained at a distance of 100 meters from a superphosphate works showed 2 milligrams fluorine per liter. A kilogram of grass absorbed 0.2 of fluorine if chiefly superphosphate was scattered.

- 187. Fluorine poisoning due to flue gases and dust from a superphosphate works. Determination of the fluorine content of the deposits on plants, in water, hay and bones.** Stas, M. E. *Chem. Weekblad*. 38: 585, 1941. (Abstr. C. A. 36: 6696, 1942) (Nov.)

Plants in the vicinity of the superphosphate works, as well as water from ditches, were examined for fluorine, calcium, and phosphorous content. "In a cow 8.5-9.5 mg. of fluorine were found per 1 gram bone ash, whereas the normal content in various regions of Holland amounts to 0.25-1 mg."

187a. Fluorine Intoxication. Roholm, K. H. K. Lewis & Co., Ltd., London, 1937.

In this extensive monograph on fluorine intoxication the author devotes parts of various sections to fluorides as air pollutants. He presents an extensive bibliography as well as his own observations to show that air pollution by fluorides emanate from certain types of industrial processes and that such fluorides cause disease in man and animals, as well as seriously damaging vegetation.

Particulate Matter

188. Report of advisory committee on atmospheric pollution on observations in the year ending March 31, 1922. H. M. S. O. 42, 1923. (Abstr. J. Indust. Hyg. 5: 145, 1923) (Nov.)

According to Dr. Owens, the air passages are not an efficient dust filter because in quiet breathing 2.5-7 percent of inspired dust reaches the depth of the lungs and in deep breathing, over 20 percent; nose-breathing does not protect against dust.

189. Toxic effects of smoke on firemen. Ann. de'hyg. 12: 490, 1909. (Abstr. Mellon Inst. Smoke Invest. Bull. No. 9, p. 40, 1914)

This exhaustive study of the effect of smoke upon health of firemen reveals the following symptoms from inhalation of soot: (1) redness and congestion of conjunctiva, tears; (2) inflammation of nasal mucous membrane and frontal headaches; (3) enlarged tonsils and redness and congestion of pharynx; (4) inflammation and edema of larynx, dry painful cough, asthmatic symptoms; and (5) bronchial or lobar pneumonia.

From work on animals, the author concluded that carbon particles play a large role in the production of serious symptoms. Slight disorders were due to the action of carbon particles on the mucous membrane. Animals exposed to filtered smoke (with soot) recover more easily than those exposed to smoke not so filtered.

190. Behavior of microscopic particles in the air and in the respiratory system. Hatch, T. F. Symposium on Aerobiology, Am. Assn. for the Adv. of Sci. Series No. 17, 102, 1942. (Abstr. J. Indust. Hyg. & Toxicol. 24: 184, 1942) (Nov.)

Particulate matter is dispersed in two ways, dynamic projection and air carriage. No general law can be said to govern the velocity and direction of the spread of particulate matter, and it can be said only that sufficient air movement exists to insure positive dispersion of the particulate matter. The respiratory tract, among other functions, serves to free inspired air from harmful concentrations of inspired dust. Its efficiency is close to 100 percent for particles of 5 microns and larger and goes down to 20 percent for particles of less

than 0.3 microns. An aggregation of particles acts as a unit, and hence the efficiency of dust removed in the respiratory tract increases with the degree of flocculation of the inspired material.

- 191. A practical approach to the problem of urban air pollution. Mills, C. A. Cincinnati J. Med. 22: 502, 1942. (Jan.)**

Contaminating factors of smoke include carbon soot, least harmful to health; fly-ash blamed for high incidence of tuberculosis, upper respiratory infection, chronic sinusitis, and silicosis; flue gases, sulfur dioxide, and others which are noxious and perhaps carcinogenic; and steam, responsible for dense smogs. It is recommended that the use of high volatile coal in the city be avoided unless it can be properly burned, steps be taken to decrease fly-ash, and that the use of non-condensation steam engines be eliminated.

- 192. Curious aspects of atmospheric pollution. Owens, J. S. Gas J. 176: 372, 1926. (Abstr. J. Indust. Hyg. 9: 163, 1927) (Aug.)**

"Deep breathing in polluted atmospheres is shown to be harmful by dust counts on inspired and expired air under various conditions of breathing."

- 193. What is known about the effect of smoke on health. White, W. C. U. S. Dept. Commerce, Bur. of Mines, R. I. 2781, 1943.**

The work to date on effects of smoke on health is reviewed, and the contention is that the evidence is indicative but not conclusive that smoke is damaging to health. A plan is proposed for further investigation. It is felt that the important components of smoke with regard to health are carbon and other dusts.

Carbon Dioxide

- 194. The value of high oxygen in physiological effects of noxious concentration of carbon dioxide. Brown, E. W. U. S. Nav. Med. Bull. 28: 523, 1930. (July)**

There is an increase of the depth of breathing and an increased rate with 4-5 percent carbon dioxide and normal oxygen. Soreness in "region of the diaphragm," fatigue, mild headache, and chilly sensation result after exposure to these levels of carbon dioxide.

- 195. Air of the city. Godfrey, H. Atlantic Monthly 102: 62, 1908.**

Even when present in the air in excessive amounts, carbon dioxide exists in far too small quantity to act in any way as a direct poison. "Normally, the carbon dioxide in the lungs is 100 times as great as that in the atmosphere."

196. The safe limit of carbon dioxide in the working atmosphere. Higley, G. O. *Am. J. Pub. Health* 8: 477, 1918.

Emphasis is placed on the need to assess the value of oxygen in the air before the effects of carbon dioxide can be adequately appraised, since death or toxic effects may be due as much to a decrease in oxygen as to the increase in carbon dioxide. Other factors which must likewise be considered are physical factors, temperature and humidity and presence of other toxic gases. From a review of the efforts of other workers, the author concludes that the safe limit of carbon dioxide in the working atmosphere is 0.2 percent.

Oxygen Deficiency

197. Inaugural address, 1882. Galton, D. *Tr. San. Instit. Great Britain* 4: 21, 1882.

Air impurity has a deleterious effect on health through the reduction in oxygen content as well as the clogging of the lungs with impurities, which reduces their power to absorb oxygen. This impure air arises from the "dust of refuse, mostly horse manure, as well as from smoke, and other products of combustion."

"The influence of smoky town air on health is to some extent illustrated by the fact that the death-rate of 23 manufacturing towns, selected chiefly by their smoky character, averaged 21.9 per 1,000 in 1880; whilst the rural districts in the counties of Wilts, Dorset, and Devon, excluding large towns, averaged 1717 per 1,000; and the deaths from the principal zymotic diseases in the towns were more than double those in the rural districts."

198. The dangers of impure air. Greely, H. *M. Rec. (N. Y.)* 87: 564-67, 1915. (April)

All the impurities of air are discussed in a generalized way. The over-all problem is considered of grave enough consequence that action or lack of action may mean the difference between health and disease. Gaseous compounds emitted from furnaces are considered to be "Poisonous" and to render the air incapable of carrying the normal amount of oxygen.

Mixed Gases

199. Smoke and fire gases, toxic constituents. Easton, W. H. *Indust. Med.* 11: 466, 1942. (Oct.)

The greater number of deaths from fires is the direct result of the action of smoke and fire gases. In this study the various constituents released during the combustion of certain materials are enumerated. It is concluded that probably most deaths are the result of carbon

monoxide poisoning. Certain substances, when burning, may release enough toxic material, such as hydrogen cyanide, ammonia, hydrogen sulfide, and sulfur dioxide, to contribute directly to the fatal event. The effect of these gases in combination is suggested to be greater than an individual effect, so that gases that are sublethal alone may form lethal concentrations when combined with other gases at sublethal levels. The author cites Hofer, who found that carbon monoxide and hydrogen sulfide, at concentrations which were not fatal when breathed alone, became fatal to animals in 10 minutes when mixed. Similar results were achieved with carbon monoxide and hydrogen cyanide. Reference is also made to Luce's work on mice which points out that most combinations of vapors in low concentrations showed additive effects.

200. On the manner in which poisonous gases and fumes exert their effect. Gaisbock, F. *Wien. Klin. Wchnschr.* 44: 937-939, 1931. (Abstr. *Bull. Hyg.* 6: 866, 1931) (Dec.)

The author lays stress on the increased danger when mixtures of gases and fumes are present, as occurs in exhaust gases from internal combustion engines, fires, and explosives used in mines. Thus mixtures of nitrous fumes and carbon monoxide developed from mine explosives, or in the burning of X-ray films have been shown experimentally to prove fatal when the amount of each gas or fume inhaled singly will produce only slight symptoms. Wirth is cited as stating that, in experiments lasting ninety minutes, inhalation of about half the mixture of the two gases proved fatal in a much shorter time than it would have with either gas singly.

Fire Gases

201. The toxicity of fire gases. Ferguson, G. E. *The Frontier* 4: 10, 1944.

This brief article describes the hazards of gases arising from burning materials. Combustion of nitrocellulose produces oxides of nitrogen; burning rubber produces hydrogen sulfide and sulfur dioxide; burning wool produces hydrogen sulfide, hydrogen cyanide, and ammonia; burning silk produces hydrogen cyanide and ammonia. The gases produced by combustible materials may produce fatalities even in the absence of serious burns.

202. Smoke poisoning. Hattingberg, M. V. and Schoen, T. *Deutsche med. Wchnschr.* 71: 88, 1946.

Irritant gases act as corrosives on the mucosa of the eyes and respiratory tract. Their effect remains limited to the surface of the tissues with which they come in contact. The greater the water solubility of a gas, the higher is the irritant effect on the respiratory

tract. Gases hardly soluble (e.g., nitrous oxide) act first at the deep parts of the bronchioles and alveoli, where the effects have more serious consequences. The nose and throat are less sensitive to the gas than is the deeper respiratory tract, and there is less chance of damage here. Corrosion of the larynx, trachea and bronchi can lead to marked edema of the glottis, severe inflammation with secondary infection, and complications in the lung. Damage to the bronchioles and alveoli leads primarily to severe disturbances of respiration, or even to fatal lung edema and possibly heart failure.

There are some protective devices against gases, but carbon monoxide can overcome these and subject the person to the deep penetration of smoke and its components. Only 0.2 percent concentration of carbon monoxide is necessary to produce carbon monoxide death. Carbon monoxide poisoning and pathology are discussed in detail.

Smoke poisoning is similar to carbon monoxide poisoning plus the additional effects of irritating gases. There are mucosal irritations of the conjunctiva and air passages with coughing, secretion of mucous catarrh, and pulmonary complications. At autopsy, the inflammatory reddening of the mucosa of the respiratory tract stands out. Lung irritants do not cause lasting damage, while the irritation of the upper respiratory tract can lead to chronic bronchitis, pulmonary fibrosis and bronchiectasis.

Fourteen cases of smoke poisoning due to large fires are reported. All cases showed irritation of the respiratory tract. The blood findings showed an increase of hemoglobin and an increase in red blood corpuscles and white blood corpuscles with a shift to the left. In all cases the symptoms of carbon monoxide poisoning could be seen. They dominate the first stage of smoke poisoning, which is characterized by the loss of consciousness. They were symptoms of irritation of the mucosa. The early lung edema may always be regarded as the result of smoke gas, especially nitrous oxide.

Soot

203. How and why smoke is injurious. Benner, R. C. Fifteenth Intern. Congress Hyg. and Demog. 3: 1015, 1912.

Soft coal is the chief contributor to smoke, which consists of carbon, mineral ash, tar, moisture, sulfur gases, and acids of nitrogen, in widely varying concentrations. Smoke and soot constitute an extremely objectionable type of dirt. Smoke blocks the stomata of plants and hinders transpiration. By covering the leaf, it decreases the available exposed surface to the sun and stunted plant growth is reported. Tar and acids have corrosive properties.

Smoke affects the weather by (1) cutting off light, (2) increasing duration of fogs, and (3) increasing minimum temperature.

204. Occupational Tumors and Allied Diseases. Hueper, W. C. C. C. Thomas Co. Springfield. 1942.

Soot, as a cause of cancer, is discussed from the standpoint of chemical and technological aspects, historical data, and geographical distribution and incidence of soot cancer. There are notes on exposure, age incidence, symptomatology, pathology, predisposing factors, experimental soot cancer, and precautionary measures. A final section is devoted to the medicolegal aspects of the problem.

205. Experimental investigation on the inhalation of coal dust. Ruppert, H. Virchow's Arch. 72: 1878. (Abstr. Mellon Inst. Smoke Invest. Bull. No. 9, 35, 1914)

This paper reports on a number of animal experiments upon dogs and rabbits to show: (1) The changes in the epithelium of the air passages that are caused by the inhalation of dust; (2) How the dust penetrates the tissue; (3) What passage it uses in entering; and (4) What forces impel it forward in the process. He concludes that soot is less harmful to the respiratory organs than is mineral dust.

Tar

206. On the cancer producing factor in tar. Kennaway, E. L. Brit. M. J. 1: 564, 1924. (Mar.)

Lignite tar, gasworks tar, producer-gas tar and coke-oven tar have been found experimentally to produce cancer in mice and rats, whereas blast-furnace tar does not.

Aldehydes

207. The removal of aldehydes from diesel exhaust gas. Davis, R. F. and Elliott, M. A. Trans. Am. Soc. Mech. Engrs. 70: 745, 1948.

This report presents the results of studies to determine the relation between aldehyde content of diesel exhaust gas and the odorous and irritating properties of that gas and to determine the effectiveness of different scrubbing media for removing aldehydes from diesel exhaust gas.

Observations on the odor and irritation produced by diesel exhaust have shown that both of these properties can be correlated with the concentration of aldehydes in the gas. The threshold concentration of perception of odor is approximately 0.2 to 0.3 parts per million of aldehydes, expressed as equivalent formaldehyde. The threshold of nasal and eye irritation occurs at about 1 part per

million of aldehydes. A series of full-scale tests on the removal of aldehydes by scrubbing with water showed that as the concentration of aldehydes in the scrubbing solution increases, the percentage removal of aldehydes decreases. At elevated temperatures, the removal was nil, and under no condition was complete removal obtained.

From a series of laboratory tests, it appeared that aqueous solution of sodium sulfite might be used in removing aldehydes from diesel exhaust gas if hydroquinone were added to inhibit the oxidation of the sodium sulfite. A full-scale test showed that an aqueous scrubbing solution containing 10 percent sodium sulfite by weight and 0.5 percent hydroquinone removed substantially all aldehydes for a period of 7 hours and 90 percent or more of the aldehydes for a period of 15 hours. In this test, approximately 3000 cu. ft. of dry exhaust gas (at 60° F. and 29.92 in. Hg) were scrubbed per hour at a scrubbing temperature of 133° F. Estimates of the cost of scrubbing diesel exhaust gas indicate that the cost of materials would be approximately 80 cents for an engine operating continuously for 8 hours and producing an average of 5000 cu. ft. of dry exhaust gas (at 60° F. and 29.92 in. Hg.) per hour.

Arsenic

208. The need for investigations in nature of damage caused by waste gases. Muhisteph, W. Chem. ztg. 66: 436, 1942. (Abst. J. Indust. Hyg. and Toxicol. 26: 138, 1944) (Sept.)

Many investigations of smoke damage during the last two decades have placed an over-evaluation on the chemical analysis of the air. Proper weight has not been given to a study of the effects and an examination of objects damaged. Arsenic and fluorides have been slighted as toxic agents with excessive emphasis given to sulfur dioxide.

209. Injury to the animal world through the distant effects of industrial waste gases. Prell, H. Arch. f. Gewerbepath. Gewerbehyg. 7: 656, 1937.

The Tharandt Zoological Institute has known that animals in certain parts of Saxony have peculiar injuries to their hair. There is sometimes a loss of hair in spots or over the entire body, the skin having a black appearance. From a study of a few skin samples, it was determined that parasites, sarcoptids or fungi could not be found as the pathogenic agents. The red deer were affected the most.

The author found the stratum corneum to be thickened. Investigation convinced him that the arsenous acid in factory fumes was

responsible. The arsenic was deposited on the ground and on vegetation as finely divided dust some miles distant from the factories.

Scleroderma together with alopecia and a strange rough appearance of the skin were found in the red deer; the individual hair had lost its cylindrical appearance and had dried up. The mucous membranes of the respiratory tract were inflamed as was the mucosa of the digestive tract. The connective tissue showed a gelatinous infiltration with noticeable thickening. There was cirrhosis and swelling of the liver in some cases. Malformation of the antlers was marked.

Three possibilities of the effect of arsenic are: (1) a direct poisonous effect of the arsenic through irritation and cauterization of the surface of the tissues which the poison reached from the outside; (2) an indirect poisonous effect on the organs through absorption of arsenic; and (3) a disposition-changing effect of arsenic. The power of the body to resist other injuries is reduced, and these other injuries lead to more serious results.

Endemic paresis noted in some red deer was also due to arsenic poisoning. The results of the investigation revealed that arsenic poisoning is amazingly widespread. Rain can wash the arsenic from the vegetation and thus pollute the streams.

Miscellaneous

210. Toxicity of Smoke. Knight and Crocker. Bot. Gaz. 55: 337, 1913.

This experiment to determine which of the constituents of smoke produces a response in plants describes the apparatus used and the histological data.

"Molisch has shown that tobacco smoke is extremely toxic to many plants." From other experiments it is evident that the smoke from the "cellulose and lignum compounds" (of tobacco plants) is rather toxic. According to Molisch, the toxicity of tobacco smoke is due to the smoke of pure cellulose. Photographs show the stunting effect of smoke from cigarette paper on the growth of seedlings. Chimney smoke was found to be very slightly toxic. It was found that smoke from cigarette paper was 500 times as toxic as the coal smoke used. In general, the injury from coal smoke has been attributed entirely to tars and the oxides of sulfur. When smoke from cigarette paper is compared with carbon monoxide, it is found to be ten times as toxic as pure carbon monoxide. The author seeks to show that reduced carbon-bearing gases are the major toxic factors in injuries from coal smoke.

Vegetation can be injured by gases undetectable to the gas analyzer because of their low concentrations.

- 211. Effect of prolonged breathing of hydrogen sulfide in dogs.** Moser, P. *Arch. f. exper. Path. u. Pharmacol.* 196: 446, 1940. (Abst. *J. Indust. Hyg. and Toxicol.* 24: 11, 1942) (Jan.)

Dogs were allowed to breathe air containing 0.01 percent of hydrogen sulfide for 7 hours daily for 2 months. The only symptom observed was some irritation of the nasal mucosa.

- 212. Atmosphere pollution in relation to tuberculosis.** Varrier-Jones, Sir P. *Dis. of Chest* 4: 8, 1938.

In this discussion the general thesis is that smoke has not been proven guilty of causing tuberculosis by means of its effect upon the respiratory tract. Various works are cited to substantiate this view. In fact, it is conceded by some, including the author, that inhalation of coal smoke has a protective effect against tuberculosis.

- 212a. The chemistry of smog.** Schrenk, H. H. *Ind. Hyg. Newsletter* 10: 7, 1950 (Mar.)

The author who was concerned with the investigation of the Donora, Pennsylvania episode, presents a discussion of the chemistry of air pollution and how to study it. He cites as an example the methods used in the investigation at Donora made by the U. S. Public Health Service.

- 212b. Factory smoke containing manganese a contributory cause of epidemics of pneumonia in an industrial community.** Elstad, D. *Nord. Med.* 3: 2527, 1939.

Morbidity and mortality studies were made on the incidence of pneumonia in a community in which a manganese extraction plant was located. It was shown that the lobar pneumonia rate, both for morbidity and mortality, was high. This is believed to be due to effluvia from the manganese plant and probably a manganese compound itself.

- 212c. Non-occupational berylliosis.** Eisenbud, M., Wanta, R. C., Dustan, C., Steadman, L. T., Harris, W. B., and Wolf, B. S. *J. Indust. Hyg. & Toxicol.* 31: 282, 1949.

Data is presented showing that cases of chronic lung diseases from exposure to beryllium occurred in an appreciable number of cases of persons not connected with the industrial occupation. These people lived in the areas adjacent to beryllium extraction plants. The data point out the findings of beryllium levels in the areas about the industrial plants.

LOCALITIES

Meuse Valley

- 213. Atmospheric pollution and pulmonary diseases. Anonymous. Brit. M. J. 1: 277, 1931. (Feb.)**

This is a report of 63 deaths in the Meuse Valley incident. Most of those who died were elderly and, in many cases, already suffering from cardiac and pulmonary disorders. Also, there were a misty fog and bitter cold weather to take into consideration. However, death appeared quickly, suggesting poisoning, and at autopsy the lungs showed irritative changes consistent with the inhalation of sulfur dioxide.

- 214. Cause of the fog catastrophe in the Meuse Valley in 1930. Anonymous. J. A. M. A. 108: 903, 1937. (Mar.)**

The mysterious fog catastrophe caused several thousand cases of disease and sixty deaths. A review is presented of a acute and chronic fluorine intoxications, and this catastrophe is shown by the author to be probably acute fluorine intoxication. Fifteen of the 27 local factories used raw materials containing fluorine, and there was the possibility of gaseous fluorine being given off in the smoke from the chimneys. Special climatic and topographic conditions played an important part in the catastrophe.

- 215. Fatal Belgian fog. Alexander, J. Science 73: 96, 1931. (Jan.)**

Autopsies performed on cows which died in the Belgian (Meuse Valley) fog showed that they had died from pulmonary edema. Highly efficient nuclei for the production of fog were furnished by dust particles in the air and the native atmospheric pollution. The newspaper reports indicate that the persons and animals were attacked suddenly with symptoms which, because of their abruptness and nature, led one to suspect that they were in the nature of anaphylactic phenomena. The time of exposure prior to seizure was too short to suggest bacterial infection. "Thus, for example, it might be possible that castor bean cake containing the poisonous protein ricin had been used as a fertilizer in that neighborhood and that some men and animals had become sensitized to it. The fog, settling, might have brought into the lungs of these sensitized beings sufficient ricin dust to occasion the onset of anaphylaxis."

216. Problems of atmosphere pollution. Batta, G.; Firket, J. and Leclerc, E. Masson et Cie., Paris, 1933. (Abstr. J. Indust. Hyg. and Toxicol. 19: 212, 1937) (May)

The authors take up in detail all questions of air impurities. They consider the physical basis for atmospheric pollution, such as the causes and kinds of impurities, the products of combustion, and industrial contaminants. The effects of these impurities on man, as well as on plants, metals, and stone, are described.

One chapter is devoted to a description of the Meuse Valley disaster of December 1930. In this disaster 64 persons died, and a thousand were taken ill. The conclusion was reached that the cause was one of a peculiar meteorological situation plus sulfuric acid formed from sulfurous acids originating from the many industrial plants. Sulfuric acid was named as the chief cause for deaths and illness. Hydrofluoric acid from one plant was considered only a secondary factor.

217. The cause of the symptoms found in the Meuse Valley during the fog of December 1930. Firket, M. Bull. Roy. Acad. Med. Belgium 11: 683, 1931.

Certain symptoms common to all were painful irritation often mounting to an active retrosternal pain, and extending along the outer edge of the ribs; attacks of coughing, dyspnoea, often paroxysmal; and prolonged expiration. Adrenalin often gave relief. Those previously affected with asthma or heart disease developed symptoms of shock. In addition to the tracheobronchopulmonary irritation, a large number showed signs of laryngeal irritation causing cough and modification of the tone of the voice. There was also some nausea and vomiting, lacrimation, and tenacious sputum. In one case there was desquamation of the mucosa of the entire buccal cavity. There was no diarrhea, neuritis, albuminuria, hepatomegaly or sensory disorders. "There is no reason to believe that only the ill and the aged were seriously affected by the toxic attacks." Persons were attacked who had not left their houses for several weeks or who had not gone out in the fog. At autopsy there was congestion of the mucous membranes of the air passages. All the symptoms and all the lesions found could be sufficiently explained by a local irritation of the exposed mucous membranes.

218. Fog along the Meuse Valley. Firket, J. Trans. Faraday Soc. 32: 1192, 1936.

Between December 1 and 5 of 1930, a heavy fog covered a large part of Belgium. A number of people were made ill; several hundred were severely attacked with respiratory symptoms, and 63 died on December 4th and 5th after only a few hours of illness. Many cattle

had to be slaughtered. On December 6, the fog disappeared. Public opinion was deeply affected by the episode, and an investigation was started immediately.

All the sick people felt retrosternal pain, had fits of coughing, and dyspnoea, and some had asthmatic attacks. In those who had asthma, cardiovascular collapse and symptoms of shock complicated the picture. In those who did not have asthma, hyperpnea, cyanosis and a tendency to frothy sputum developed. The autopsy reports indicated that the noxious substance was inhaled during the last few hours of life. The first symptoms began on the third day of the fog. Respiratory symptoms disappeared on the sixth day when the fog abated. Symptoms were observed by the people throughout the valley at about the same time.

Chemical Analyses: The chemists found thirty substances polluting the atmosphere, with maximum concentrations reached by carbon monoxide, carbon dioxide, nitrous gases, sulfur dioxide, and hydrogen fluoride. Through deduction, observation, and data obtained, sulfur dioxide appeared to be issued in the largest amount in the whole valley as a result of burning coal. Part of the sulfur dioxide was oxidized into sulfuric acid. Only by the action of sulfur pollution could the simultaneous illnesses occurring along the entire valley be explained. The pathological findings also favored sulfur dioxide and sulfur trioxide as the offending gases.

219. Atmospheric pollution and fogs. Haldane, J. S. Brit. M. J. 1: 366, 1931. (Feb.)

This report and discussion of the Meuse valley catastrophe of December 1930 states in part: "The sulfuric acid is present in the air as minute liquid droplets of dilute sulfuric acid, condensed on solid nuclei, while the sulfurous acid is present as a gas. . . . These particles are evaporated to a much greater extent inside buildings, though acid nuclei still remain and make the air inside just as irritating as that outside. Many Liege victims had never been outdoors at all."

220. Sulfur dioxide or hydrofluoric acid poisoning? The fog catastrophe in the industrial region of Luttich. Van Leeuwen, W. S. Chem. Zentr. 1: 807, 1933; (Abstr. C. A. 28: 5152) 1934. (Aug.)

"The cases of poisoning in the Meuse Valley in December 1930 were due to the formation of a fog loaded with the waste gases of numerous factories, chiefly sulfur dioxide and hydrofluoric acid. According to Fenner the poisoning effect was caused by the fluorine silicate or fluorsilicic acid in the factory gases."

- 221. Expert findings on the cause of the accidents that occurred in the Meuse Valley during the fogs of December 1930. Mage, J. and Batta, G. *Chimie et industrie* 27: 961, 1932. (April)**

This report covers many phases of the Meuse Valley incident, including a section on the medical findings.

It appears that most of the ill persons were elderly and included a large number of asthmatics and cardiacs. There was some illness among healthy adults and children. Deaths were generally ascribed to cardiac failure. Autopsies showed a diffuse congestion of tracheal mucosa and large bronchi. Soot particles were observed free in the pulmonary alveoli.

There is a section which discusses the possible causative agent in the episode and the conclusion is reached that it was most likely compounds of sulfur, especially sulfur dioxide.

- 222. The role of hydrofluoric acid in the toxicity of the fog in the Meuse Valley in 1930. Mage, J. and Batta, G. *Chimie et industrie* 30: No. 4, 787, 1933. (Abstr. C. A. 28: 1808, 1934)**

The authors explain why the theory of the role of fluorine compounds as the principal agent in the Meuse disaster is untenable.

(1) The accused factory from which hydrogen fluoride was supposed to have been released was running at less than one-fourth normal activity at the time. (2) Only a small part of the fluoride in the new materials was released. (3) Wind, although almost nil, was blowing in a direction from Liege toward Huy, and this plant producing hydrogen fluoride is down wind from the disaster area. (4) Since this plant was the only source of hydrogen fluoride in the valley, the appearance of symptoms should have occurred first near the plant, whereas actually symptoms appeared simultaneously over a wide area, suggesting many sources for the toxic substance. (5) The amount of sulfur released was much greater than was fluoride.

- 223. On the cause of the fog catastrophe in the valley of the Meuse, December 1930. Roholm, Kaj. *Hospitalstidende* 79 1936. (Abstr. Air Pollution, An Annotated Bibliography. School of Medicine, Univ. of S. California, Los Angeles, Calif.)**

This article discusses this catastrophe, which was accompanied by several thousand illnesses and 60 deaths. It concludes that the probable cause of the illness and death was the concentration of toxic fluorine compounds, produced by 15 of the 27 factories located in the valley, and blanketed near the ground by the peculiar atmospheric conditions which existed at the time. A map of the Meuse

valley area involved, showing the towns, industrial plants, and locations of the deaths, is included.

224. **The fog disaster in the Meuse Valley, 1930: A fluorine intoxication.** Roholm, K. *J. Indust. Hyg. & Toxicol.* 19: 126, 1937. (Mar.)

The thesis of this paper is the cause of the Meuse Valley incident with an attempt to place the blame on fluorine and its compounds. This report, written long after the disaster, suggested that the subject of fluorine, and its compounds, and their toxicity were not understood at the time of the disaster. The author claims that his data, together with a better understanding of fluorine toxicity, places responsibility on such compounds as the cause of the incident.

225. **Fog catastrophe in industrial section south of Liege.** Van Leeuwen, W. S. *Munchen. med. Wehnschr.* 78: 49, Jan. 9, 1931. (Abstr. *J. of Indust. Hyg.* 13: 159, 1931) (Sept.)

After three days of fog in the Meuse Valley, a large number of people complained of irritations in the nose, mouth, throat, trachea and bronchi. The mucous membranes were red and swollen. Necropsies later revealed that these inflammations reached down into the bronchi. In the serious cases dyspnea, dilatation of the heart, rapid pulse, and cyanosis developed. Signs of pneumonia were not present. Epinephrin brought temporary relief. Among those ill and those who died, were persons with asthma, bronchitis, and heart disease. However, previously healthy young persons also became ill. The 63 fatalities all occurred within 24 hours and in the narrow valley south of Liege. The author believes lack of oxygen was not responsible. More important as a cause are the toxic irritative gases emitted by the industrial plants in the area. These include sulfur dioxide and hydrofluoric acid.

Donora, Pennsylvania

226. **Fluorine gases in atmosphere as industrial waste blamed for death and chronic poisoning of Donora and Webster, Pennsylvania, inhabitants.** Anonymous. *Chem. Eng. News* 26: 3692, 1948.

Circumstantial and actual proof has been found of acute fluorine poisoning by the smog in the Monongahela River Valley of persons who already had chronic fluorine intoxication, states a report of investigations of the cause of the deaths of seventeen people in Donora, Pa., and of three in Webster during the last week-end in October. Most of the well-known symptoms of acute fluorine poisoning were found by members of the medical profession who examined victims of the smog, Philip Sadtler, consultant, discovered.

For four days, the fog bank across the tops of valley walls surrounding the towns had permitted little movement of air and allowed the gaseous waste products of several plants and the railroads to accumulate. Besides being saturated with soot, the fog blanket also contained sulfur dioxide, carbon monoxide, and hydrofluoric acid. It has not yet been shown that the first three were present in quantities sufficient to kill. Numerous factors, however, indicated fluorine poisoning, Mr. Sadtler states. Fluorine-containing substances are used in several plants in the vicinity. Analysis of the blood of the deceased and of hospitalized victims showed 12 to 25 times the normal quantity of fluorine. Corn crops, very sensitive to fluorine, were severely damaged and all of the vegetation north of the town was killed. One of the primary symptoms of acute fluorine poisoning in human beings, dyspnoea (distressed breathing similar to attacks of asthma), has been found in hundreds of cases. Although those who were affected were of all ages, those who died had displayed symptoms similar to those of chronic fluorine poisoning much earlier. Conspicuous evidence of such chronic poisoning in young persons in the vicinity is the high incidence of mottled tooth enamel and dental caries. Moreover, many effects of secondary fluorine poisoning are to be seen in herbivorous animals in the region. Lastly, inanimate objects show evidence of attack by acid gases.

Recommendations for improvements call for completion of the study in order to single out the plants, materials, and processes causing the trouble. Changes should be made in suspect processes to prevent emission of fluorine-containing fumes, and improvements in combustion are needed. Cottrell precipitators to collect dust and scrubbers to absorb the acid gases are also essential, Mr. Sadtler concludes.

227. Smog, a formidable health menace, say hygienists. Anonymous. Chem. Eng. News 26: 3622, 1948.

In this staff report on the 13th annual meeting of the Industrial Hygiene Foundation, general remarks on health hazards of industrial gases were made. It was announced that the U. S. Public Health Service will undertake a comprehensive study of the nature and effects of contamination of the atmosphere by industrial wastes.

228. The Donora smog disaster—a problem in atmospheric pollution. Fletcher, R. D. Weatherwise 2: 56, 1949.

Fletcher, of the U. S. Weather Bureau, describes the weather conditions which gave rise to the Donora incident. His article is based on news reports, Pittsburgh airport weather data, and Donora weather report data.

- 229. The Donora disaster.** Shilen, J. *Indust. Med.* 18: 70, 1949. (Feb.)

Contains data on sulfur dioxide determinations made during the smog.

- 229a. The Donora smog disaster.** Mills, C. A. *Hygeia* 27: 684, 1949. (Oct.)

From an investigation made by the author and by lay persons, he describes his findings in the case of the Donora, Pennsylvania, episode. He points at the local industrial plants as being responsible for the episode, suggesting some of the irritant gases which could have given rise to the acute illnesses and the fatalities. He ends with a plea for cleaner air, not only in this community, but in others in the United States.

- 229b. The Donora disaster.** Mills, C. A. *J. A. M. A.* 140: 556, 1949. (June 11)

In this letter to the editor the author complains about the fact that a governmental agency (the U. S. Public Health Service) is investigating the Donora, Pennsylvania, smog episode. It is his suggestion that private practitioners of medicine should engage in this study.

- 229c. The Donora episode.** Mills, C. A. *Science* 111: 67, 1950. (Jan. 20)

The author, who made a brief investigation of the Donora, Pennsylvania, episode of October 1948, presents a criticism of the report of the U. S. Public Health Service (Public Health Bulletin No. 306). He believes that the data presented in that report indict the "red oxides of nitrogen" as the cause of the illnesses and the deaths. This was not so believed by the Public Health Service investigators. Mills comes to his conclusion by placing a theoretical "lid" over the valley and calculating the amount of gas that would accumulate during a given period of time.

- 229d. The Donora smog disaster.** Shilen, J., Mellor, J. F., Jr., Stang, A. M., Sharrah, J. S., and Robson, C. D. *Penn. Dept. of Health, Bureau of Ind. Hyg.*, (Oct. 1949?).

This report is based partly on air tests made towards the end of the episode in Donora, Pennsylvania. It is suggested that sulfur dioxide, found in appreciable amounts, was the cause of the illnesses. Morbidity and mortality studies were also reported. These indicated, through dental examinations, that fluorides were probably not the cause of the illnesses; and, through chest X-rays, that chronic pneumonitis did not occur in the community. The mortality studies showed that death rates from cardiorespiratory diseases were not unusually high in Donora.

229e. Donora; the case of the poisoned air. Davidson, B. Collier's Weekly, Oct. 22, 1949, p. 20.

This is a news report of a lay observer of the episode which occurred in Donora, Pennsylvania, during the latter part of October 1948, when during a smog thousands of persons became ill and 20 died.

It details some "human interest" stories, and gives some of the highlights of the report of the U. S. Public Health Service, which made a detailed scientific study of the episode.

229f. Air Pollution in Donora, Pennsylvania. Schrenk, H. H., Heimann, H., Clayton, G. D., Gafafer, W. M. and Wexler, H. Pub. Health Bull. No. 306, 1949.

In the latter part of October 1948, Donora, Pennsylvania, a town of about 13,000 population, containing a zinc plant and a steel and wire plant, experienced a large number of acute illnesses and 20 deaths during a heavy smog. This report is based upon a carefully made epidemiological study, approached from the biological, the engineering, and meteorological points of view.

The data collection began after the episode was over and included: (1) Studies of acute morbidity by house-to-house canvass, records of fatal and hospitalized patients, and, finally, study of general morbidity; (2) Study of chronic morbidity by dental examinations of school children, by certain chest roentgenograms, and morbidity of selected groups of individuals; (3) Study of mortality records of the community and comparing them with similar records of neighboring towns; (4) Atmospheric studies of air pollutants; (5) Evaluation of industrial plant effluents; (6) Evaluation of air contaminants from other sources; (7) Description of the topography of the valley in which the town is located; (8) Micrometeorological studies of the valley; (9) Description of the weather during the acute episode in October 1948.

Detailed descriptions of the methods used are presented since it was believed they would be useful to others making similar studies.

The study showed that the cause of the episode was an accumulation in the atmosphere of chemical irritants, this accumulation resulting from the weather inversion which existed in this part of the country during the fateful days. The parts played by all sources of chemical air contamination are discussed. A section is devoted to discussing the specific agent or agents probably responsible for the illnesses, and it is deduced that no one agent can be indicated. It was likely that it was due to a chemical irritant (possibly sulfur dioxide) plus particulate matter, although, because of the lack of

knowledge about the toxic effects of low concentrations of the irritant gases, this cannot be said with certainty.

Los Angeles, California

- 230. Smog ceases to be joke to industrialists spending millions of dollars to control waste gases.** Anonymous. *Iron Age* 163: 104, 1949. (April)

In this general discussion of preventive measures taken by private industries in Southern California, specific reference is made to installations in industrial plants. Mention is made also of the problems faced by industries in Oregon and Washington, where claims have been made that fluorine fumes are injuring livestock and crops.

- 231. Preliminary report; air pollution investigation, County of Los Angeles, California.** Deutch, I. A. and Rich, P. C. *Los Angeles; Office of Air Pollution Control, June 2, 1947.* (Abst. Atmos. Poll. Bull. 16: 12, 1948) (July)

This investigation was planned as a preliminary study which would disclose some of the important points of the local air pollution problem and could serve as the preliminary phase of a future comprehensive study having the following aims: determination of the nature, extent and cause of atmosphere contaminants causing eye smarting and lachrymation, and of those responsible for reduced visibility, with a resulting increase in hazards; measurement of the nature, extent of and degree of air pollution and evaluation of the importance of the smoke aspect to the whole problem of air pollution in the county; and development of regulations for discharge of aerial wastes other than smoke in metropolitan Los Angeles. The present report contains a preliminary study of the problem with special sections dealing with aerial waste investigation, source studies, vital statistics, and analysis of weather bureau data.

- 232. Technical aspects of the Los Angeles smog problem.** Johnstone, H. F. *J. Indust. Hyg. & Toxicol.* 30: 358, 1948. (Nov.)

The southwest and west winds carry the dust and fumes of the industrial district over the city. At times the air becomes stagnant, and low visibility, high temperature, and humidity increase the irritation to the eyes, nose and throat. The sulfur dioxide concentration is usually considered a good index of the degree of industrial contamination of the air. There are some indications that sulfur dioxide may contribute directly to smog formation. Sulfur trioxide and sulfuric acid contribute to mist formation. Removal of sulfur compounds from waste products is difficult. About the only forms

in which sulfur can be used as a raw material or chemical agent in any quantity are elemental sulfur, hydrogen sulfide, sulfur dioxide and sulfuric acid. Many of the smog-contributing industries were started during the war, when smoke-eliminating equipment could not be made and when air pollution control was lax. This must be remedied and new methods employed to alleviate the smog situation.

233. General atmospheric pollution: Los Angeles "smog."
Senn, C. L. Am. J. Pub. Health 38: 962, 1948. (July)

It is pointed out that the smog problem in Los Angeles occurs in the summer and fall rather than winter, as elsewhere. Temperature inversion in which the air temperature is as much as 30° higher than surface temperature is shown to occur. Air is then held on the ground, and smoke lingers. Smoke sources are tabulated with indicated control measures. The smog contains component or components which are irritating to the eyes. An investigation into sources of irritation was unsuccessful so that the offending irritant has not been identified. The possibility that a change in gases or chemicals may occur after they have been released into the atmosphere is suggested. Meteorological and airplane investigations are being carried on to gain additional knowledge with regard to pollution source.

Pittsburgh, Pennsylvania

234. Report on Stationary Stacks. Ely, S. B. Bureau of Smoke Prevention, Pittsburgh Department of Public Health, 1948.

This report is a review of the work done during the year 1948 by the Pittsburgh Bureau of Smoke Prevention. It has to do with all the stationary stacks within the City of Pittsburgh. A separate report covering railroad smoke conditions is issued.

Sulfur dioxide is suggested as the likely toxic agent at the Donora disaster, and it is not considered likely that Pittsburgh could have such a disaster because of the small amount of sulfur dioxide emitted there.

An analysis is given in percentages for substances collected in cans throughout the Pittsburgh area during the year 1948. The highest concentrations of substances in the dust were sulfur trioxide, 18.9 percent; ferric oxide, 13.97 percent; silicon dioxide, 12.3 percent; and zinc oxide, 7.5 percent. The only item considered poisonous was lead oxide, which was only .005 percent of the total and therefore thought to be harmless. The sulfur trioxide represents all kinds of sulfur compounds so that gaseous sulfur compounds were a much smaller percentage. It is emphasized that all dust that falls

in the cans is not directly from combustion, but much may be blown up from the ground.

Graphs are included showing results of dust collection comparing 1948 with 1938; a marked reduction is shown for the former.

St. Louis, Missouri

235. Does smoke abatement pay? Levitt, A. Courtesy of J. H. Carter, Commissioner, Div. of Smoke Regulation, Dept. of Public Safety, City of St. Louis. Private correspondence, Nov. 14, 1946.

Some factors are presented indicating the desirability of smoke abatement. The St. Louis project is cited. Smoke reduction is shown in percentages after the enactment of smoke abatement legislation. Direct monetary losses due to smoke, which include clothing cleaning bills, painting, refinishing, house and building cleaning, and loss in merchandise are given. Mentioned also are increase in medical care costs and lowered morale. Attesting to the value of smoke abatement, many statements of various physicians are quoted as testimony to the decreased incidence of mucous membrane irritation, colds, sinusitis, and infections of the tracheobronchial tree. Eye specialists are also quoted as to the reduced irritation of conjunctiva and infection. The reduced difficulty in keeping buildings and grounds cleaned with a great reduction in carbon deposits is a noteworthy effect of smoke abatement. Business men are quoted as to the reduction in cleaning costs and the reduced loss of merchandise. It is estimated that savings in light bills amounted to \$75,000 per annum.

London, England

236. The smoke evil (London letter). Du Plessis, J. J. A. M. A. 105: 1533, 1935. (Nov.)

Statistics showed a close relation between death rates and atmospheric conditions. The number of deaths from pulmonary and cardiac diseases increased in direct proportion to an increase in the intensity and duration of smoke fogs. Increased tuberculosis of the lungs was produced. Tarry matter of smoke is suspected to cause cancer. Psychologic ill effects were interrelated with the physiologic. Smoke gloom lessened the potential reserve, working power and well-being of the individual.

Dublin, Eire

237. Atmospheric pollution in Dublin during the year 1941. Leonard, A. G. G., McVerry, B. P., and Crowley, D. *Sc. Proc. Roy. Dublin Soc.* 23: 10, 1942. (Abstr. *J. Indust. Hyg. & Toxicol.* 25: 139, 1943) (June)

Owing to the shortage of coal, the total pollution due to suspended matter was only one-half of the average for the preceding three years. The number of deaths from respiratory diseases during that winter was the lowest recorded in the years during which the investigation was carried out. At Leinster Lawn, the total pollution by sulfur dioxide was 60 percent of the average of the previous three years.

238. Atmospheric pollution in Dublin during the year 1942. Leonard, A. G. G., McVerry, B. P., and Crowley, D. *Sc. Proc. Roy. Dublin Soc.* 23: 161, 1943. (Abstr. *J. Indust. Hyg. & Toxicol.* 26: 126, 1944) (June)

Sootfall measurements for 1942 are given. Graphs comparing pollution with temperature and with deaths from respiratory diseases from 1938 to 1942 are presented. Periods of lowest temperature are the periods of maximum pollution, and these are followed by a maximum in deaths from respiratory diseases in Dublin. There was a decrease in pollution following a coal shortage for the winter of 1940. Deaths in January 1942 and 1943 were the lowest in the entire period studied but still above summer maximums. The authors conclude that, if records were kept over a sufficient period of time, it might be possible to differentiate between increased deaths in winter due to pollution and those due to other causes. Sunlight was measured for the two periods, but no conclusions were drawn.

239. Atmospheric pollution in Dublin during the year 1940. Leonard, A. G. G., McVerry, B. P., and Crowley, O. *Sc. Proc. Roy. Dublin Soc.* 22: 399, 1941.

Measurements of substances, both solid and gaseous, found in Dublin's air were made and the results tabulated in several tables.

Several graphs are included, one of which shows relation of pollution to deaths from respiratory disease.

Glasgow, Scotland

240. Pollution of the air by smoke. Owens, J. S. *J. State Med.* 42: 51, 1934. (Jan.)

Air today is laden with irritating substances which affect people suffering from bronchial diseases. The worst sufferers are the men

who do heavy labor since they breathe more deeply than sedentary workers. A table is given for London and Glasgow for 1915 to 1933, listing the deposits of total solids and sulfates (as sulfur trioxide). Tables express the total monthly deposit of 29 English cities.

Manchester, England

241. **The Smoke Evil.** Anonymous. *J. A. M. A.* 105: 1533, 1935. (Nov.)

Statistics show a close relation between death rates and atmospheric conditions. The number of deaths from pulmonary and cardiac diseases increased in direct proportion to an increase in the intensity and duration of smoke fogs. Tarry matter of smoke is suspected of producing cancer in the lung.

Manchester received only 55 percent of the daylight received by a neighboring town on a still day, and only 5 percent on a foggy day. Therefore, there could be no assimilation of calcium and phosphorus through the action of ultraviolet rays. Rickets and anemia developed.

Smoke gloom lessened the potential reserve, working power and well-being of the individual. Garden produce and pasture land have been so reduced by smoke that lettuce supply has been reduced to only 31 percent of the natural yield.

Miscellaneous

242. **Smoke in the atmosphere.** Anonymous. *Brit. M. J.* 1: 674, 1934. (April)

This study of atmospheric pollution by smoke in Lancashire reveals that insoluble material was in highest concentration in the center of town whereas soluble material was more widely distributed. Atmospheric pollution caused a marked reduction of sunlight and, in particular, of ultraviolet radiation.

This is an editorial discussing in part the contents of a book by Ashworth, "Smoke and the Atmosphere," which is a documentary study from records kept in the Lancashire area since 1916. Principally, the concern is on settled dust readings with no mention of correlation with health.

243. **Atmospheric pollution in Toronto, Canada.** Barrett, H. M. *Canad. Pub. Health J.* 29: 1, 1938. (Jan.)

A controlled experiment conducted as part of the Toronto investigation showed that smoke in concentrations normally occur-

ring in urban atmospheres diminished the ultraviolet energy to an extent where it ceased to prevent rickets in rats. Four tables, indicating four collection areas for smoke particles, and listing soluble and insoluble matter, total solids and sulfur dioxide in tons per square kilometer, are given. The atmospheric pollution of Toronto is compared graphically with London and with several United States cities.

244. The amelioration of atmospheric pollution. Green, H. W. Am. J. Pub. Health 21: 237-41, 1931. (March)

Collection stations throughout Cleveland revealed 23 percent carbon and 77 percent ash, of which 30 percent was ferric oxide. Not collected were gaseous elements as carbon monoxide, carbon dioxide, ammonia, chloride, nitrous acid, nitric acid, sulfur dioxide, sulfur trioxide, sulfurous acid, hydrogen sulfide, all of which have detrimental aspects such as corrosion of metals and pathological effects on plants and animals. The sources for these contaminants are discussed. Recommendations are made for the amelioration of those pollution factors.

245. City smoke and its effects. Ives, J. E. and Sayers, R. R. Pub. Health Rep. 51: 15, 1936.

Points stressed in this statement regarding smoke control in the District of Columbia were imperfect combustion and waste of fuel, extra expense of cleaning clothes, disfigurement of buildings, injuries to plant life, loss of daylight, and injuries to health.

SUNLIGHT ASPECTS

- 246. Smoke menaces health. Anonymous. Safety Engineering 92: 56, 1946. (Dec.)**

Smoke deprives cities of their sunlight. In one large American city, smoke deprived the community of 21.5 percent of its sunlight on an average day. It was also found that 25 percent of the ultraviolet rays were cut off on passing through 200 feet of the city's air. Smoke in some urban communities absorbs 58 percent of the antirachitic rays from the sun. A smoke abatement program is discussed.

- 247. Effect of air pollution on health: report of the Committee on Public Health Relations. Bull. New York Acad. Med. 7: 751, 1931. (Sept.)**

A review of literature on air pollution and its effect on health is included. Substances which pollute the air are discussed in some detail with emphasis on sulfur. Also mentioned are arsenic, carbon monoxide, chlorine, and oxides of nitrogen. Instruments and methods for investigating air pollution are mentioned.

Effects on general health include loss of adequate sunshine and the depressing effect of clouds and fog. A marked decrease in ultraviolet rays from the sun was postulated as a large factor in the incidence of rickets, tuberculosis, anemia and infections in general. An analysis is made of sunlight lost and reasons for this loss, which include the season, humidity, clouds, and velocity of wind. The high incidence of respiratory diseases in England is cited, as in the correlation of decreased mortality in one town in which a prolonged coal strike reduced smoke. Present legislation usually deals with visible smoke without requiring dissipation of invisible noxious substances. Irritation of the eyes, particularly by carbon particles, leads to increased incidence of conjunctivitis. The inferiority of artificial light to sunlight for vision is stressed. Vegetation is injured by air pollution. There is an increased morbidity and mortality to tuberculosis in polluted areas.

- 248. Loss of light due to smoke in New York. Anonymous. Heating and Ventilating 28: 87, 1931. (Jan.)**

Loss of light was greater in cloudy days than when sunny; for the same kind of sky, clear or cloudy, the average percentage loss of light increased with increase of relative humidity. During clear

weather, the average percentage loss was twice as great for a relative humidity of 65 percent as for 35 percent. For a cloudy sky, the increase with relative humidity was not as great. The percentage loss of light decreased as wind velocity increased.

- 249. Loss of light in New York City due to smoke. Anonymous. Pub. Health Reports 45: 2032, 1930. (Aug.)**

The relative loss of light in various parts of New York City, is considered. The results showed that loss of light depends, among other things, upon altitude of the sun, nature of daylight (clear or cloudy sky), relative humidity, and velocity of the wind. There was a large relative loss of light at the Hudson Street Marine Hospital due to smoke.

- 250. The antirachitic effect of ultraviolet radiation transmitted by a smoky atmosphere. Barrett, H. M. J. Indust. Hyg. 17: 199, 1935. (Sept.)**

This is a technical paper describing the measurement of loss in antirachitic potency of the radiations from a quartz arc lamp after passage through an atmosphere of smoke, and an attempt to correlate the results with external conditions. Albino rats were used, and the criterion was comparison by bony calcification. Determinations were made of bone ash, blood phosphorous, and X-ray changes in bone. Compared results were significant in proving the smoke reduced the radiation with loss of antirachitic properties. A review of literature is cited to correlate findings with external conditions.

- 251. Atmospheric pollution and sunlight. Drinker, P., Thomson, R. M. and Choate, S. P. A.S.M.E. 52: 45-48, 1930.**

Ultraviolet and visible light are of clinical importance. Atmospheric pollution decreases light. Data, in the form of graphs and tables, correlate daylight and dust in the atmosphere. Admitting a lack of adequate, comparative data, however, the authors are unable to draw definite conclusions as to what extent pollution reduces the effectiveness of sunshine.

- 252. Smoke nuisance. Gibbons, J. O. G. Power 67: 303, 1928. (Feb.)**

Smoke eliminates ultraviolet rays which are necessary for health. Several statements unsupported by figures, regarding the deleterious effect of smoke on health are given.

- 253. Effect of light on health. Hill, L. Gas J. (London) 168: 569, 1924. (Nov.)**

Fresh air and sunshine along with splints are beneficial in curing children of rickets, tuberculosis of the spine or joints. It is the ultraviolet rays which are the most beneficial. Clothes, glass, mist and smoke cut off the ultraviolet rays. There is a discussion and

classification of these rays. A lack of ultraviolet rays, through smoke obstruction, is detrimental to vegetable life. The death rate increases when a combination of smoke, fog, and white frost occurs.

254. The obstruction of light by smoke and its effect on health.

Hill, L. M. *Officer* 56: 213, 1936. (Nov.)

This technical paper, explaining the effects and benefits of sunlight, shows that the shortest wave lengths of the ultraviolet rays cause sunburn and are of greatest importance to health. Cloud, fogs and smoke pollution, by absorption, decrease the energy of the direct sunlight enormously and screen off all the short ultraviolet rays. The sun has a curative effect on wounds and is of greatest value in tubercular patients and in rickets. Smoke lessens these beneficial effects.

255. Loss of light due to smoke in Baltimore, Maryland from October, 1929 to September, 1930. Ives, J. E. *Pub. Health Reports* 48: 113, 1933. (Feb.)

This study was made to determine the loss of light due to smoke during the years 1929 and 1930 in Baltimore. Measurements were made within the smoky part of the city and also outside the city where the air was comparatively free from smoke. The difference between the two was taken as loss of light due to smoke. The highest average daily horizontal illumination outside the city occurred in July and the lowest in December. The greatest total loss of light (due to smoke) in the city was also in July and the least in December.

The average loss for the year was 13.2 percent for clear days, 15.9 percent for cloudy days, and 14.1 percent for all days. Other factors affecting the light loss besides clouds were relative humidity and the wind velocity and direction. Light loss was greater for the higher relative humidity. The percentage loss of light for clear days decreased as velocity of wind increased. The average loss was greater for southerly winds.

256. The evaluation of the minimal prophylactic dose of anti-rachitic radiation for rats. Kay, K. K. and Barrett, H. M. *J. Indust. Hyg. & Toxicol.* 29: 41, 1947. (Abst. C. A. 41: 1725, 1947) (Mar.)

The amount of ultraviolet radiation of wavelength 2697-3042 Å. necessary to prevent rickets in rats was determined. One million seven hundred thousand ergs/1sq. cm. from these wavelength administered in 30 daily doses of unshaved rats resulted in a bone ash value of 46 percent and normal calcification as indicated by x-ray photographs. Four million three hundred thousand ergs per sq. cm. produced normal bone ash levels. The earlier results of the effect of smoke on the absorption of ultraviolet energy were ex-

tended. The determination of the spectral transmission of wood smoke for 2967-600 A. indicates that no considerable change in transmission occurs with change in wavelength for smoke atmospheres with particle diameters of 0.2-2.0 microns. On the basis of this observation, the use of nonselective methods should give correct values of the absorption of solar ultraviolet energy by atmospheric smoke.

- 257. Effects of air contaminants on the natural light of cities.** Meller, H. B. and Warga, M. E. *Am. J. Pub. Health* 23: 217, 1933. (Mar.)

The primary purpose of the paper is to give some data obtained from 12 months' continuous records of ultraviolet radiation. Nothing is noted of the effect on health of loss of radiation due to smoke.

- 258. Effect of atmospheric pollution upon incidence of solar ultraviolet light.** Schrader, J. H., Coblenz, M. H. and Korff, F. A. *Am. J. Pub. Health* 19: 717, 1929. (July)

Determinations were taken in and around Baltimore, using lithopone and methylene, blue acetone methods of recording variations in ultraviolet, and catch cups for a measure of particulate matter. The results reveal that atmospheric pollution was only one-sixth as great in the country as in the center of Baltimore, and that ultraviolet light was 50 percent greater. They also conclude that carbon, as tarry products, is materially more inhibitive to the incidence of ultraviolet light than siliceous material.

- 259. The Smoke Problem of Great Cities.** Shaw and Owens. Constable and Company, Ltd., London, 1925.

This book, which is devoted to the problems of smoke in large cities, discusses meteorological aspects, nature and origin of smoke, industrial uses of smoke, the economic aspect, measurement of atmospheric pollution, numbers and kinds of polluting particles, and methods for smoke abatement. Some sections are briefly devoted to the health aspects of smoke. The loss of sunlight is especially discussed.

- 260. Relation of sulfur dioxide in the atmosphere to photosynthesis and respiration of alfalfa.** Thomas, M. D. and Hill, G. R. *Plant Physiol.* 12: 309, 1937.

The process of photosynthesis involves delicate and complicated chemical reactions under the influence of light. These reactions are readily affected by external conditions. Fumigation with 7.0 parts per million of sulfur dioxide caused about 95 percent leaf destruction on alfalfa. The plant rapidly oxidizes sulfur dioxide to a sulfate, which is the form in which plants use sulfur for their nutrition.

261. Loss of actinic intensity in urban sunshine due to air pollution. Tonney, F. O., Hoeft, G. L., and Somers, P. P. *J. Prev. Med.* 4: 139, 1930.

Air pollution cuts off the shortest ultraviolet rays first, thus reducing actinic intensity which is greatest in the short ultraviolet rays. Erythema range is principally 3020-2970 Å, which coincides with the antirachitic range.

In the study, cloudless days were used for uniformity, with test stations dispersed about the city of Chicago and control stations outside and windward to the city. Most severe obscuring effects were observed in late fall and early spring. In summer, when combustion of fuel for heating is at a minimum, the loss of ultraviolet light is still considerable. Studies were made over a three-year period.

EFFECTS ON VEGETATION

- 262. Sulfur dioxide in the atmosphere. Anonymous. Steam Engineering 9: 159, 1940.**

This is a brief resume of the results of various studies on sulfur dioxide content in the air of cities in Great Britain and the United States. The paper by Whitby on his studies of the effect of sulfur dioxide on vegetation at Trail, British Columbia is summarized. This and other investigations surrounding the Trail, British Columbia problem are considered to be the most valuable work on the effect of sulfur dioxide on vegetation.

The editorial strikes a note of caution on the amount of guilt which should be assessed on sulfur dioxide in plant damage. A case is cited in which the yellowish discoloration of a species of clover was believed to be due to sulfur dioxide, but later studies revealed that the actual cause was a deficiency of boron in the soil. The products from the carbonization of coal, of which ethylene is an important offender, are stated to be much more deadly for plant life than sulfur dioxide. The importance of a careful study for all possible toxic factors in any investigation is stressed.

- 263. Effect of sulfur dioxide on vegetation. Anonymous. Nat'l. Research Council (Canada) Rep. No. 815, 1939.**

This collection of fifteen papers and a summary covers eight years' field experience and fumigation experiments by a group of scientists working under the Associate Committee on Trail Smelter Smoke. They were to obtain scientific data for the use of an international tribunal appointed to settle claims of alleged damage to crops in Stevens County, Washington, by smelter fumes from Trail, British Columbia.

- 264. The smoke nuisance. Anonymous. The Builder, 77: 143, 1899. (Aug.)**

The lethal effect on vegetation was noted in this protest against the increased smoke over industrial areas of England. Better combustion of coal is suggested as the answer to the smoke nuisance.

- 265. The conservation of the nation's vegetation: the effect of smoke on plant life. Ascroft, R. W. Knapp, Drewett and Sons, London and Kingston-on-Thames, 1926.**

Smoke is responsible for extensive damage to vegetation. Sulfur dioxide is formed from the burning of coal. Sulfur dioxide forms sulfur trioxide, which, combined with water, forms sulfuric acid, which in turn enters into the soil. The harmful effects of sulfuric acid on plants, vegetation and trees are discussed. Animals feeding on smoke-affected pastures often do not survive. Some soils are so acid that they must be constantly limed. Plants affected by smoke acted as though they had been dipped in hot water. The leaves, buds and flowers fell off. Experiments were conducted, painting solutions of powdered metallic iron, red oxide in water, and sulfurous acid on plants. Marked damage was done by the acid, but there was practically no effect caused by the others. Tar products from inferior coal produce harmful effects on vegetation. The pyridine and phenol of tarry material appear to be unusually poisonous to plants. Fog also diminishes light to plants and thereby checks transpiration.

266. Rationalizing smoke abatement. Azbe, V. J. Third International Conference on Bituminous Coal, 593, 1931.

Smoke exerts a detrimental effect on plants in three ways: (1) It blocks pores, impeding transpiration; (2) it coats the leaf reducing transmission of sunlight; and (3) it is likely to exert a poisonous effect directly on the plant or indirectly on the soil.

For the first effect, the sticky tarry ingredients are blamed. A film is created over the leaf causing the second effect. The sulfur gases are blamed for the nature and elimination of smoke, and to the sources and measurement of atmospheric pollution. Some of the methods for combatting the smoke problem are discussed.

267. Nature and extent of air pollution by smoke. Cohen, J. B. and Ruston, A. G. Nature 81: 468, 1909. (Oct.)

The report contains the results of measurement of impurities at 10 stations. Impurities are broken down into quantities of each type of contaminant, such as soot, tar, sand, minerals, sulfur dioxide, chloride and nitrogenous matter. The tarry constituents were considered most harmful to plants, and these were most highly concentrated in the residential districts. The total sulfur was found to be high everywhere, but particularly in manufacturing areas, and the sulfurous acids were considered to give to town fog its choking and irritating effects.

To demonstrate the detrimental effect of sulfuric acid on timothy grass, tests were performed in which the control grass received acid-free water, while experimental plants were watered with ordinary rain water from Leeds and from Garforth. With Leeds water, the grass became yellow to brown, and this water was shown to have

a high acid content. In the other plants where acid was absent or negligible (as at Garforth), there were no deleterious effects noted.

- 268. The nature, distribution, and effect upon vegetation of atmospheric impurities in and near an industrial town.**
Crowther, C. and Ruston, A. G. *J. Agr. Sci.* 4: 25, 1911. (Abstr. U. S. Dept. Agr. Exper. Station Record 25: 434, 1911)

Investigations and observations (1906-1910) at Manor Farm, Garforth, and Leeds are summarized. The work comprised analyses of rain samples and the effects of certain classes of atmospheric impurities upon vegetation. Rain samples were assessed for their impurities. Atmospheric pollution influences plant life by (a) reducing intensity of sunlight, (b) blocking stomatal openings, and (c) exerting a toxic influence through the sulfide constituents of the air. This influence affects the plant directly or indirectly through the soil.

Controlled experiments with timothy grass demonstrated that acidified water of 16 parts sulfuric acid per 100,000 parts water, used for irrigation, proved fatal to the grass in little over a year. At 32 parts per 100,000 the grass died in six months, and no vegetation was visible the following spring. Other concentrations of lesser amounts were used, and it was observed that in every case the yield steadily decreased with increased acidity of the water. The effects in this respect were cumulative. Concentrations showing this cumulative effect compared with concentrations of acid in rain water falling in industrial areas. The experiments thus were analogous to natural events inasmuch as concentrations of acid in the water were comparable. The cumulative effect upon timothy grass resulted in a product poorer in protein and richer in crude fibre, and thereby less nutritious.

- 269. Injury to vegetation and animal life by smelter waste.**
Haywood, J. K. *U. S. Dept. of Agriculture Bull.* 113, 1910.

This is a report of a study to determine the injurious effects which wastes from plants smelting sulfide copper ores may have on vegetation and animal life. Effects of sulfur dioxide on certain vegetation were first determined experimentally to see if sulfur dioxide was actually injurious and the type of injury it caused. Observations of actual damage were made at and around the Anaconda, Montana, smelter. In the experimental investigation, sulfur trioxide content in foliage was determined and compared with controls, and in all cases the exposed trees contained a higher concentration than the controls. In the field investigation, observations as to general appearance, types of growth, and sulfur trioxide content, were made of foliage about the smelter. These observations were made during the summer of 1908. General conclusions included: (1) From actual

chemical analysis it appeared that the forests extending at least 10 miles north, 11½ miles east, 9½ miles south, and 15 miles west, of the smelter were injured. (2) It was noted that the junipers were very resistant to smelter fumes, while the red firs were very susceptible and were badly damaged at distances of from 18 to 19 miles from the smelter; the lodge pole pines were damaged for at least 10 or 11 miles. (3) Large quantities of arsenic were discharged from the smelter and settled on the grass of cattle ranges as far as 15 miles away. Such arsenical grasses are not a suitable feed for cattle.

- 270. Effect of sulfur dioxide on vegetation.** Holmes, J. A.; Franklin, E. C.; and Gould, R. A. U. S. Bur. Mines Bull. 98: 1915.

Several fresh, vigorous plants (arbor vitae, grapevine, peach limb, and apple limb) were exposed experimentally to the action of sulfur dioxide mixture. No appreciable damage was observed except on the grapevine, the leaves of which were bleached.

- 271. Smoke injury to shade trees.** Jennings, O. E. Tenth National Shade Tree Conference, Proc. of Annual Meeting 1934. (Abstr. C. A. 29: 4042, 1935)

Sulfur dioxide at a concentration of only a few parts per million may cause burned streaks and spots on the leaves; leaves or parts of leaves with a scant water supply seem to be the most seriously affected. Clogging of the stomata by dust or soot is not as harmful, but it is a serious matter to have the surface of the leaves covered by a layer of dust, particularly dark-colored sooty matter which prevents light entering the leaf tissues. Under conditions existing in Pittsburgh, the resistance of trees to sulfur dioxide and dust is, in the descending order; Chinese tree of heaven, ginkgo, Carolina poplar, pin oak, London plane, liquidamber, Normay maple, the elms and European linden.

- 272. Agriculture and smoke pollution.** Jones, H. T. Gas J. 231: 206, 1940.

This paper is a collection of observations made in the course of advisory work in Yorkshire, during the previous 15 years, of the effect of smoke fumes on vegetation. Smoke absorbs solar energy and reduces the assimilating power of the leaves. The sulfur in the smoke becomes oxidized to sulfuric acid, which burns up the plants. Thus vegetation growing near industrial sites is inhibited or stunted in its growth due to the action of sulfur compounds.

- 273. Effect of sulfur dioxide on vegetation.** Katz, M. National Research Council (Canada) No. 815: 1939.

This book describes an extensive study made in Canada of the effects of sulfur dioxide on vegetation. The investigation was prompted

by the numerous litigations of American farmers near the Trail, British Columbia, Smelter, charging that smoke from the smelter spread in varying concentrations into a valley in the United States thus causing undetermined damage to crops and other vegetation. This is a very complete treatise on the subject. Part I describes the results of field studies: sulfur dioxide in the atmosphere of industrial areas, symptoms of injury on forest and crop plants; the sulfur content of trees and shrubs in relation to sulfur dioxide in the atmosphere; sulfate content of soils; sulfate content of water supplies; and, the effect of sulfur dioxide on the diameter increment of conifers. Part II consists of fumigation experiments.

- 274. Symptoms of injury on forest and crop plants.** Katz, M., Ledingham, G. A. and McCallum, A. W. National Research Council (Canada) Pub. No. 815, 1, 1939. (C.A. 34: 5884, Sept. 10, 1940)

Most damage is done to crops and plants in the early part of the growing season when sulfur dioxide combines with high humidity. Symptoms of acute and chronic injury to plants are described.

- 275. Sulfur dioxide in the atmosphere and its relation to plant life.** Katz, M. Paper presented at the American Chemical Society Meeting, San Francisco, March 28-29, 1949.

Sulfur dioxide from industrial gases is widely distributed in the atmosphere in low concentrations. When found in concentrations higher than approximately 0.4 parts per million it may be toxic to sensitive plants during periods of the growing season when physiological activity is high and conditions for the rapid absorption of this gas by leaves are at a maximum. However, low concentrations, in the range up to 0.10 to 0.20 parts per million, do not appear to have any visible effect on plant life. Long, continued exposure to such low concentrations has had no effect on rate of growth, yield of crop, photosynthesis, or respiration. Such exposure may be beneficial by providing a nutrient if plants are growing in a sulfur-deficient soil. No basis in fact has been found for the theory of invisible injury.

The literature on the subject is reviewed, and the results of the investigations carried out by the writer and his collaborators on various aspects of the sulfur dioxide pollution problem are presented. Topics include: (1) The occurrence of sulfur dioxide in the atmosphere of industrial areas; (2) the sulfur content of vegetation; (3) the effect on soils; (4) symptoms and diagnosis of injury from sulfur dioxide and other factors; (5) retardation of diameter increment in conifers; and (6) experimental studies on the influence of environmental factors on susceptibility, the effects on conifers in natural

habitat and transplanted stock, and on the yield of crop plants, stomatal behavior, and photosynthesis and respiration.

276. Detection of fluoride in plants injured by fluorine. Kurger, E. Metall. u. Erz 38: 265, 1941.

Plants suffer injury when exposed to fluorine fumes from industrial plants. Fluorine may also be found in plants that have been exposed to calcium fluoride powder. Plants, without exception, will show injury after exposure to fumes of fluorine; therefore, unless such injury is apparent, the presence of fluoride is of little significance. The microchemical detection of fluoride by the Feigl and Krumholz method is considered good, but Bredemann's method, based on the formation of sodium silicofluoride, is preferred. In several hundred analyses this method has never failed, and it is unaffected by fluoride present as a natural constituent of the plant. Plants as far as almost a mile from the source of fluorine fumes are affected. This is a relatively small distance in comparison with the effective range of sulfur dioxide.

277. In report on the effects of urban fog on cultivated plants to the scientific committee. Oliver, F. W. Roy. Horticult. Soc., 1893.

The various substances found in London urban fogs which have become polluted by smoke are discussed. The sulfuric and sulfurous acids are conceded to be the important noxious elements, although other substances are believed also to have a deleterious effect on plants. These include hydrochloric acid, ammonia, metallic iron, ferric oxide, hydrocarbons, phenol, and some of the members of the pyridine series.

Various types of injuries to plants, such as discoloration and disarticulation of the leaves, are mentioned. The type of damage peculiar to each type of plant is also discussed. The effect of loss of light due to air pollution is discussed as another contributor to plant injury.

278. The plant as an index of smoke pollution. Ruston, A. G. Ann. Applied Biol. 7: 390, 1921.

The variation in susceptibility in various types of plants to smoke damage suggested to the author that carefully selected varieties might be used as indicators of smoke pollution. The conifer is considered the most sensitive plant, while hollyhock is considered the best indicator of smoke pollution. The general appearance of the exposed plants is discussed. The brown splotches and other changes in leaves are considered the best index. Other measurements are annular rings and chemical analysis of sulfur trioxide content in leaves.

- 279. The effects of smoke on vegetation.** Ruston, A. G. *Proc. Science Museum Conference. National Smoke Abatement Society*, 23, 1936.

Smoke may affect vegetation in the following ways: (a) The smoke cloud decreases available sunshine. (b) The tarry matter coating over the leaves will tend to check, if not prevent, the natural process of transpiration and assimilation. Microscopic examination actually reveals choked stomata filled with this tarry material. (c) The presence of free acids in the smoke-polluted air lowers the vitality of plants. Loss of vitality is shown by poorer colors and reduced reproductive power as demonstrated by controlled experiments. (d) The effect of smoke is cumulative, through deposition of the acid in the soil. Tests were performed on various soils to determine acid content and yield. In all cases a close correlation existed between plant growth and acidity. Other changes in soil exposed to a polluted atmosphere were found to be a steady depletion of calcium carbonate and the inhibition of the soil organisms, particularly the important nitrifying ones.

- 280. The Land, Now and Tomorrow.** Stapledon, R. G. *Faber and Faber*, London, 1935.

This book is devoted to a study of the land of Great Britain and its total utilization from the national point of view for agriculture, forestry, rural industries, recreation, and other purposes. Atmospheric pollution is condemned as a far worse enemy of agriculture than is generally thought, and it is pointed out that the cleaning of the air is a project that should be handled on a nationwide basis.

- 281. Effect on sulfur gases in industrial smoke on vegetation.** Turrell, F. M. *Citrus Leaves* 25: 6, 1945. (Abstr. *Atmos. Poll. Bull.* 14: 20, 1946) (June)

This is a discussion of the effect of sulfur dioxide on vegetation, particularly with respect to the adverse effects on citrus trees, arising from increased industrialization in the Los Angeles area.

- 282. The effects of sulfur dioxide on vegetation.** Whitby, G. S. *Chemistry & Industry* 58: 991, 1939. (Nov. 11)

A discussion on the effects of sulfur dioxide on vegetation as observed at Trail, British Columbia. The investigation was carried out over a period of eight years, 1929 to 1937, and was considered the most extensive study ever made on the effects of sulfur dioxide on vegetation. The concentration of sulfur dioxide at the United States border was carefully determined throughout the crop season at a point 16 miles from the source of sulfur dioxide. Maximum and average concentrations in part per million are given.

The sulfur content of vegetation was determined and was found

to diminish as the distance from the smelter increased. It was determined that the sulfur content may rise to four times the normal amount without injurious effect. This is particularly so with prolonged low concentration. The effect on the soil was determined by measuring soluble sulfate, pH and exchangeable bases. The soil near the plant was affected, but this fell off rapidly with increase in distance so that eight miles from the smelter the soil was substantially normal. No effect on water supplies was found.

An appreciable retardation in growth, as determined by annular rings, was noted for trees exposed to the sulfur dioxide. This effect was lost following installation of sulfur dioxide control at Trail. Conifers were found more susceptible during periods of active growth than when dormant. Also, transplanted conifers were more severely affected than native trees. Seedlings were less resistant than older trees.

Environmental effects: any factor favoring active photosynthesis (opening of stomata) favored sulfur dioxide absorption, which increased injury.

283. Atmospheric pollution from sulfuric acid plant fumes. Withrow, J. R. Chem. Met. Eng. 26: 972, 1922. (May)

The author discusses methods of determining the percentage of fumes escaping into the air and the effect of humidity, light, temperature and duration of exposure in connection with vegetation exposed to sulfuric acid fumes.

284. Toxicity of air containing sulfur dioxide gas. Zimmerman, P. W. and Cocket, W. Contrib. Boyce Thompson Inst. 6: 455, 1934.

Experiments were carried out on the effects of sulfur dioxide on plants. The following observations were made.

1. Plants showed certain injuries which were characteristic for the species and for the age of the tissues involved. Leaves were not uniformly attacked. The middle-aged leaves were the most sensitive.

2. All other factors being equal, the amount of injury varied with the concentration of sulfur dioxide and the length of the fumigation period. Buckwheat was the most susceptible species.

3. It was most difficult to obtain uniform plant material. It is indicated that internal conditions at the time the plants are fumigated may control the entrance of sulfur dioxide and thereby affect the resistance of the plants. The degree of turgidity of the leaves was the most important factor. Wilted plants were more resistant than turgid plants because the epidermal pores were closed, and sulfur dioxide supposedly could not enter the tissues. Plants kept in the dark for several hours prior to fumigation were more resistant

than those kept in the light. However, the wilted plants offered more resistance than those in a darkened chamber. It seems as though the internal condition of the plants is more important than the external factor.

SOURCES OF POLLUTION

Chemical Manufacturing

285. Pollution control at large chemical works. Harlow, I. F. and Powers, T. J. *Ind. Eng. Chem.* 39 (5): 572, 1947. (May)
Efforts made and methods used by the Dow Chemical Company to eliminate odors, irritants, and aerosols are described.

Smelter

286. Injury to vegetation by smelter fumes. Haywood, J. K. U. S. Department of Agriculture, Bur. of Chem. Bull. 89, 1905.

Extensive observation and experimental work was carried on. It was concluded that sulfur dioxide, when present in the air in very small quantities, kills vegetation and that such injury shows itself by the increased sulfur trioxide content of the foliage.

287. Injury to vegetation and animal life by smelter fumes. Haywood, J. K. *J. Am. Chem. Soc.* 29: 988, 1907. (July)

The smelting of sulfide copper ore releases three wastes which may be injurious to vegetation or animals. These are sulfur dioxide, arsenic, and copper. From the work at Redding, California, the author concludes that sulfur dioxide in very minute amounts kills vegetation. Such injury shows itself by an increased sulfur trioxide content of the foliage. The vegetation for several miles around the smelter is injured. From the work at Anaconda smelter, the author concludes that vegetation for 7-15 miles from the smelter is seriously injured. Junipers are very resistant, red firs are very susceptible, and lodge pole pines are intermediate. Large quantities of arsenic are discharged and are found in forage crops. Waste discharged into Deer Lodge River renders it unfit for irrigation purposes.

288. Report of the Selby Smelter Commission. Holmes, J. A.; Franklin, E. C.; and Gould, R. A. U. S. Dept. of Interior, Bur. of Mines Bull. No. 98: 1915.

After questioning and testing individuals with various concentrations of sulfur dioxide ranging from 1 part per million up to 20, it was found that the average individual familiar with sulfur dioxide odor could detect its presence in 3-3.5 parts per million, and one

not familiar with the odor, in 4-5 parts per million. It was pointed out that chemists' opinions as to what concentration constitutes a nuisance vary widely, ranging from 3 parts per million to over 20 parts per million. Further, physiological effects were not manifest below 5 parts per million. Most individuals experienced throat irritation and coughing at 10 parts per million. As the concentration was increased, the throat and chest irritation became more acute. Five hundred parts per million caused a sensation of suffocation. Nausea appeared with concentrations higher than 50 parts per million.

To determine the effect of sulfur dioxide on man, experimentation was carried on, using 60 subjects divided into two groups—those familiar and those not familiar with the odor of sulfur dioxide. Veterinary studies on animals exposed to the smoke and sulfur dioxide revealed a high incidence, or over 8.5 percent, of roarers in a survey of all horses in the smoke zone near the smelter stacks at Selby.

Steam Locomotives

- 289. The smoke nuisance.** Anonymous. *J. A. M. A.* 134: 111' 1947. (May)

Coal-burning steam locomotives constitute one of the most serious single health menaces in urban air pollution. They discharge into the atmosphere (1) carbon particles containing "carcinogenic" tars, (2) fly-ash, which is irritating to the respiratory tract, (3) noxious gases, of which sulfur dioxide is the worst, and (4) exhaust steam which in cold weather remains as a steam cloud. These locomotives are significant contributors to the 500 to 800 foot smogs. One-fourth of the total atmospheric pollution in the Chicago area is from locomotives, and it is suggested that diesel engines may help to solve this problem. Deaths from pneumonia, tuberculosis and respiratory cancer are higher in smog areas.

- 290. Atmospheric conditions and physiological effects produced on trainmen by locomotive smokes in the Aspen and the Washatch Tunnels of the Union Pacific Railroad.** Kinney, S. P. *U. S. Bur. Mines, Rep. Invest. No. 2494*, 1923.

Carbon monoxide is the offending gas; temperatures and humidity are increased; and asphyxiation is possible in passing through tunnels. Descriptive data on the tunnels are given. Recommendations include the use of smoke deflectors, the breathing of air from the train's air lines, the wearing of gas masks, and a reduction of the time spent in the tunnels by increasing speed.

291. Degree of air pollution shown in survey of cities. Anonymous. *Science News Letter*, 35: 74, 1939. (Feb.)

Home fires are considered the greatest offenders, especially in regions where coal has a high sulfur content. The results of a 15-month survey of five American metropolitan areas show that St. Louis had the highest average concentration of sulfur dioxide, 0.128 parts per million. The concentration was dependent in a good measure on the wind velocity and the season.

292. Smoke abatement. Anonymous. *Annual Report, Edinburgh Public Health Department* 3: 179, 1938.

It is felt that smoke is definitely harmful to health and that smoke abatement programs should seek to become more effective. Domestic smoke is considered to be more injurious than that from industry. Methods are suggested to reduce the smoke menace.

293. Air pollution. Kershaw, J. B. C. *Nineteenth Century* 106: 471, 1929.

Generalized statements are made on the control of air contaminants, and sootfall tables for various towns of Great Britain are given. Domestic fires are considered the chief source of contaminants.

294. Aerosols. Lohse, H. W. *Canad. Chem. & Met. Eng.* 21: 340, 1937.

It is well recognized that an exposure to polluted air, especially certain fumes and dusts, for a substantial length of time is detrimental to health and human efficiency. We inhale $37\frac{1}{2}$ pounds of air daily; therefore, anything we inhale may be detrimental to our health. The air pollution problem is closely connected with the problem of fuel economy. Facts show that air pollution of cities is due to the inefficient combustion of domestic furnaces. In a set of figures, the author compares that composition of soot from the top of a domestic chimney, the chief cause of air pollution, with that from the top of a factory chimney.

295. The Smokeless City. Simon, E. D. and Fitzgerald, M. Longmans, Green, London, 1922.

This treatise on the problem of smoke abatement emphasizes the part that domestic chimneys play in the production of smoke. The domestic smoke is considered a far worse offender and more difficult of handling. The filth caused by smoke is stressed. The resultant loss of sunshine through a cloudy atmosphere is said to be detrimental to health because of the loss of its bactericidal effect, its stimulating effects, and its health-giving capacities.

Miscellaneous

- 296. Aerial nuisances from the refining and burning of petroleum oils.** Gage, S. D. *Am. J. Pub. Health* 23: 97, 1933. (Feb.)

Because no indisputable bad health effects can be assessed to air pollution (particularly by foul, odorous material), it was thought that steps toward correction might be taken on the basis that the repulsiveness of the odor leads to digestive and other disorders. The wide individual variation in susceptibility to odors is discussed. This investigation covers: (1) origin and cause of odors, (2) degree of magnitude of the odor, and (3) effect, if any, of odors on health.

The effects of odor were tabulated according to the complainants' symptoms, which included throat irritation, headache, nausea, suffocation. The illness of 96 people was attributed directly to pollution by refining of high sulfur petroleum. The 96 cases are broken down as follows: Eighty-nine, on inquiry by the author, said that their illness was caused or aggravated by the odors. Seven cases were reported by physicians as illnesses caused or aggravated, by the odors.

- 297. Southern California foundries studying and testing methods to overcome "smog" air pollution.** Murdock, O. *Iron Age* 162: 168, 1948.

This is discussion of some of the efforts being made and experimentation with foundry industries in Southern California for reducing the volume of smoke released. This interest is in response to the general concern over the smog, which reduces visibility and, on severe days, causes irritation of the eyes of persons in the downtown area.

- 298. Motor fumes and atmospheric pollution.** Regan, C. J. *Chemistry and Industry* 51: 605, 1932. (July)

The author feels that too little attention is given to the pollution of the air by motor exhaust fumes. Estimates are given of gallons of fuel used for the years 1911, 1921, 1931, showing the marked increase. Carbon monoxide is regarded as the most important constituent contaminating the air. It is released as 6.5 percent of the total exhaust gas, with 72.8 cubic feet produced per hour with a car running at 20 miles per hour. Reporting on various investigators' determinations of carbon monoxide in cities, which varied from 3.4 to 17 parts per 100,000, Keeser, Froboese and Turman wrote that in their investigation the concentrations rarely got above 20 parts per 100,000 and hence there is "no danger to acute carbon monoxide poisoning of ordinary street users." Traffic police are considered to be in a more hazardous position with as much as 30 percent carbon saturation of hemoglobin being reported at the end of tours of

duty of traffic police. These same authors found that exhaust condensates cause lung injury in mice, but it is not believed these products would exist in a high enough concentration in the street to cause injury.

299. Protecting the worker and the neighborhood at the West Upper Silesia Coke Works. Kappe. Zentr. f. Gewerbehyg. Unfallverhüt. 26: 249, 1939. (Abstr. C. A. 34: 6045, 1940) (Sept.)

Kappe discusses the fire, explosion and health hazards resulting from gases, liquids and dust produced in coke works.

- 300. Atmospheric contamination. (editorial) Anonymous.**
J. A. M. A. 110: 1839, 1938. (May)

While air pollution is hygienically undesirable, definite proof is still lacking that smoke is significant from the standpoint of health.

- 301. The bacteriology of soot. Holman, W. L. Mellon Instit. Indust. Research, Smoke Invest. Bull. No. 9: 104, 1914.**

In a brief summary of previous work on related subjects, it is pointed out that views and conclusions varied widely as to the effects of smoke or soot on microorganisms. Microorganisms were said by some to be increased in the air in the presence of smoke, while other workers held the opposite view. In the present investigation the author reported on the results of observations on the growth of bacteria in two culture media, one of which was exposed to soot. The medium containing soot showed a definitely smaller growth than that not exposed to soot. General conclusions were that soot is definitely bactericidal and that this action is due not only to the acids contained in soot but also to some other agents, probably some of the phenols. It was also concluded that soot acts as a barrier to the destructive action of sunlight on microorganisms.

- 302. Atmospheric factors during the influenza epidemic of 1933 in Kiel (Germany). Horing, F. O. Deutsche Gesells f. Inn. Mediz. Verhandlungen 45: 393, 1933.**

Granting that the direct cause or etiology is a living organism (virus), the author presents certain meteorological or climatological data which point to a definite part that climate and weather play in the production of an influenza epidemic. The weather conditions were considered unusual at the time of the influenza epidemic (1933) in Kiel. During the epidemic, Kiel lay in the center of a high pressure region and the change in the weather came at the same time that the epidemic ended. Other factors in weather of significance are humidity, temperature, weather fronts, winds, and polar and tropical air masses.

- 303. A study of air pollution in New York City. Pincus, S. and Stern, A. C. Am. J. Pub. Health, 27: 321, 1937. (April)**

The loss of ultraviolet light causes increased morbidity due to tuberculosis, rheumatic fever, rickets, and respiratory infections,

and also results in a lowered tone and vitality of the populace. In this study, all fuel going into New York City for 1934 was analyzed as to type, amount, and distribution. Also summarized were the types of fuel-burning equipment. Sootfall measurements were made at stations throughout the city during the year. Measurements of concentrations of streptococci and pollen were also made at various points. The study was made in part to bring up to date the sanitary regulations regarding smoke and air pollution in New York City and to form a basis for long-range planning.

304. Climate in the treatment of disease. Encyclopaedia Britannica. 11th ed. 6: 526, 1911.

The most important atmospheric considerations in relation to health are stated to be (1) chemical composition of atmosphere, (2) solids floating in air, (3) means and extreme temperatures, (4) degree of humidity, (5) diathermancy, (6) intensity of light, (7) electrical conditions, (8) density and pressure, and (9) prevailing winds.

With ordinary ranges of humidity and temperature, the nasal mucous membrane completely saturates the air with aqueous vapor. In cold and dry mountain climates, there is a very free nasal secretion—more than enough to saturate the air—while at low levels the reverse is true with the nose becoming “stuffy.” The mechanism on which this depends is found in the erectile tissue, and anything favouring the engorgement of veins, such as weak heart action, chronic bronchitis, or kidney disease leads to a corresponding turgidity of the nose and sinuses. In addition to barometric and other influences, it has been found that light produces collapse of this tissue, smoke having a similar effect. This latter effect probably accounts for the fact that many asthmatics are better off in a city like London than elsewhere since the smoke relieves the turgescence of the inferior turbinate of the nose.

305. Some work in Pittsburgh air pollution problems—General atmospheric pollution. Ely, S. B. Am. J. Pub. Health 38: 960, 1948. (July)

This is a discussion of the air pollution problem in Pittsburgh and how it is handled. Two problems, smoke and dust, are involved. The author cites smoke as the easier to correct and mentions some of the steps that Pittsburgh has taken. The importance of weather conditions is stressed as a factor in the amount of pollution. Particular attention is drawn to inversion in weather, in which material is held close to the ground surface. One study disclosed no difference in air pollution as measured by a recording device during the period of a mill strike and a period of activity, thereby stressing the importance of weather. Pollution was increased in mornings and evenings when inversion is most prevalent.

- 306. Climate and disease IV. Pneumonia; Influenza; Diarrhea in Children; Asiatic Cholera.** Hinsdale, G. *Bull. Am. Meteorol. Soc.* 18: 226, June-July, 1937. (Abstr. *J. Indust. Hyg. & Toxicol.* 20: 4, 1938) (Jan.)

This is a review of the effects of climate and weather on the incidence of respiratory and diarrhoeal diseases. The evidence presented is almost wholly statistical and the author points out the various contrasting views as to the mechanism of action.

- 307. Atmospheric pollution of American cities for the years 1931 to 1933.** Ives, J. E., Britten, R. H., Armstrong, D. W., Gill, W. A., Goldman, F. H. *Pub. Health Bull.* No. 224, 1936.

Part I. Origin and nature of the study:

The aim of the study was to determine the average conditions of the air in large American cities and to obtain information of value in planning future programs for smoke abatement. Fourteen of the largest cities of the United States were selected. Washington, D. C. was used as a control city because of its unusually slight air pollution. Details of previous studies are given.

Part II. Description of instruments, technique and records.

Part III. General level of atmospheric pollution:

This has been limited to the winter months in order to concentrate attention on a period that atmospheric pollution would be expected to be the greatest. This study is based on suspended impurities; former analyses were based on settled dust. Data are given for the average results of the study for all the cities for the winter months. The 14 cities are divided into three groups according to extent of pollution.

Part IV. Composition and particle size of suspended and settled dust.

Part V. Seasonal and diurnal variation in atmospheric pollution:

Atmospheric pollution was found to vary widely with the season, reaching a maximum in the winter and a minimum in the summer. Findings were based on the amounts of contaminants caught by automatic air filters. During the coldest part of winter, air pollution was about twice as great as in midsummer. As for the constituents, carbon is in greatest concentration in the winter, whereas, ash is greater in the summer, and silica does not vary much with the season.

- 308. Atmospheric influences in development of lobar pneumonia in childhood.** Kielhorn, E. *Ztschr. f. d. ges. exper. Med.* 89: 656, 1933.

This article discusses factors in the atmosphere which may be

connected with the incidence of lobar pneumonia during childhood. Such considerations as temperature, humidity, air movements, and seasons are discussed. Neither smoke nor atmospheric pollution are taken into account as factors.

309. Air pollution. Meller, H. B. and Sisson, L. B. Arch. Record 75: 277, 1934. (Mar.)

The source and general problem of polluted air are discussed. The effects of pollution on meteorological conditions depend on size of city, rate of production of impurities, and the rate at which wind and convection currents can carry the impurities away. Fogs may form more quickly, reach a greater density and be prolonged in the presence of smoke. Studies in Baltimore and New York indicated one-sixth less sunshine, on the average, in those cities in contrast to outlying areas.

The smoke, dust and gases are detrimental to growth and to fruit bearing vegetation. This is evidenced by external and internal appearance, and by yield.

The psychological and hygienic aspects of air pollution are considered closely allied. A smoggy atmosphere irritates the mind as well as the respiratory tract. There is often a feeling of depression translated into nervousness. The effects on the body range from mild irritation to a serious or even a fatal event. None of the solid or gaseous products of combustion can be said to be wholly harmless in relation to human health.

HISTORICAL NOTES

310. *Fumifugium: or the smoke of London dissipated*, 1661; reprinted 1772, 1822, etc. Evelyn, J. National Smoke Abatement Society London. Edition, 1933.

This is one of the earliest reports against the growing smoke nuisance of London, discussing its effects on buildings, gardens, and health and giving recommendations for its abatement. The author recognizes that individuals living constantly in an environment of smoke develop a tolerance to it not appreciated by a newcomer. But he feels that it is to be considered how much longer and happier one would live in a cleaner atmosphere. The effect of a smoky atmosphere on the respiratory tract is emphasized by describing the incessant "barking," "spitting," "coughing and snuffing" in the churches and other assemblies of people. The consequence of this polluted air is that almost one-half of the deaths in London are the result of "Phthisical and pulmonic distempers." The inhabitants of London are never free from "coughs and importunate rheumatisms, spitting of impostumated and corrupt matter." Members of the College of Physicians consider the smoke a "preservation against infections" although the "more learned" amongst them renounce this opinion. The contaminants in smoke responsible for much of the effects are reported to be sulfur and arsenic fumes.

311. *On the influence of the impurity or purity of the external air on health and moral tendencies of a dense population*. Ellison, R. C. *Tr. San. Instit. of Great Brit.* 4: 222, 1882-1883.

In this early protest against the smoke menace, those who claim that smoke is healthful are criticized. Smoke is considered a large contributor to urban pallor and debility as well as ills and maldevelopment of children. No specific causes and effects are discussed.

312. *A history of coal mining in Great Britain*. Galloway, R. L. London, 1882.

This discourse on the development of coal mining and the use of coal in Great Britain describes the obstacles which were met and the methods of combatting them. One of the early problems was that the majority of the populace had an aversion to the use of coal because of the disagreeable smoke. Even as far back as the 13th century, coal smoke was considered to be very detrimental to

health. At the beginning of the 14th century the use of coal, with its consequent smoke, had increased so much in London that a royal proclamation was issued (1306) prohibiting the use of coal.

313. Light, air and fog. Poore, G. V. Tr. San. Inst. Great Britain 14: 13, 1883. (Feb.)

The cause, conditions and effect of dense smoke fogs on health are considered. Continued fogs are shown to cause greater pollution of the atmosphere and these are of longer duration. Irritating matter is said to be the cause of the increase in death rates after a fog. Following one of the fogs, a severe epidemic of influenza occurred and lasted six weeks. The author felt that the cold connected with fogs had much to do with tuberculosis, pneumonia and bronchitis.

Sodium disulfide and carbon disulfide are listed as the most important gaseous constituents of fogs. Sunlight is decreased by fogs, and this loss is reflected in a higher incidence of rickets and anemia.

314. The atmosphere in relation to human life and health. Russell, F. A. R. Smithsonian Institution, Annual Report, p. 203, 1895.

The various constituents of the atmosphere are enumerated, and the relation of each to human life and health is discussed. Air-borne diseases are also discussed. A small generalized section is devoted to noxious gases.

315. On town fogs and their effects. Russell, W. J. Transactions, Seventh International Congress of Hygiene and Demography: Section V: Chemistry and Physics in Relation to Hygiene, 5: 11, 1891.

In 1891, an increase of death rate was noted with the heavy London fog.

315a. Atmospheric pollution. Townsend, J. G. Ind. Hyg. Newsletter 9: 5, 1949 (Oct.)

A brief history of the studies on air pollution and its development in the United States are presented. This is followed by a general discussion of the subject.

The subject of smoke, as differentiated from gases and vapors, is discussed, as well as the part played by the weather.

GENERAL REVIEW

316. Smoke. Anonymous. *Fortune*, 15: 100, 1937. (June)

Three kinds of materials comprise the bulk of smoke: carbonaceous matter (carbon, soot and tar), ash (mineral matter), and sulfurous gases. Smoke is suspected of causing high death rates of pneumonia and influenza, of complicity in sinusitis, conjunctivitis, anemia, rickets and cancer of the lungs, of decreasing the available ultraviolet light, of creating a psychological depression, and of "rotting" (corroding) buildings.

According to some reports, nine-tenths of the smoke stays indefinitely in suspension; the heavier particles settle out over the community—depending upon the wind direction and weather. The Public Health Service found that the peak of pollution came in the winter; that the degree of pollution varied with temperature and time of day and inversely with wind velocity; that the cleansing effects of the rain are surprisingly small, and that wind, wind direction and topography are vastly influential.

It is suspected that the greater share of smoke in the wintertime is from either domestic sources or small, one-boiler factories, rather than from large plants. Smoke-pollution damage runs into the thousands of dollars in large cities.

To correct the vast amount of smoke put out into the air daily, these suggestions are made: (1) Wash the coal before firing and eliminate 25–50 percent of the sulfur as well as some of the ash; (2) remove 95 percent of the solid content of smoke by smoke reducers, of which the Cottrell electrostatic precipitator is best; (3) utilize and burn the coal more efficiently.

317. How the courts look upon the air pollution nuisance. Bloomenthal, L. R. *Heating, Piping, Air Conditioning*, 12: 111–13, 1940.

In spite of the fact that the latest and most efficient design in equipment is used and that local regulations are strictly adhered to, a nuisance may still exist. In this case, a large creamery in Kansas is the accused. According to the Supreme Court, where the case was finally judged, no business, however lawful or modern, may be carried on in such a manner which interferes with the comfortable enjoyment of adjoining residential property. There are

occasions where the court upholds atmospheric pollution as being justified—that “public interest in the continued operation of this plant (an artificial gas plant) outweighed whatever damage might be caused to private property (a greenhouse, in this case).” Even when a neighborhood is of a predominantly industrial character, owners of a residential property are entitled to freedom from noises and odors which affect their health.

318. **Smoke, A Study of Town Air.** Cohen, J. B. and Ruston, A. G. London, 1925.

Soot consists of carbon, tar, ash, sulfur, arsenic and nitrogen compounds. Several charts on the analyses of soot are listed. The adherence of soot to buildings is shown in photographs. The effect of soot on vegetation is explained. Of the gaseous impurities, sulfur acids wither vegetation, damage masonry, and corrode metal. The other gases are each discussed separately. Without dust there would be no fog, mist, rain or dew. The formation of fog and pollutants are discussed. Photographs demonstrate the effects of soot and smoke on vegetation in different areas. Tables indicate that the greater the smoke concentration, the higher the death rate is.

319. **Bibliography of smoke and smoke prevention.** McClelland, E. H. Mellon Instit. of Indust. Research, Smoke Invest. Bull. No. 2, 1913.

This exhaustive bibliography of the literature concerning smoke and smoke prevention is a useful guide for work occurring prior to 1913.

320. **Smoke; the Problem of Coal and the Atmosphere.** Marsh, Arnold. Faber and Faber, London, 1947.

The first three chapters of this book discuss the nature of smoke, the reasons for its formation, and the extent to which it pollutes the atmosphere. Chapters 4 and 5 describe the consequences of air pollution as they affect the individual and the community. Chapter 4 is devoted to the effect of smoke on health. Considered insidious, but more important than other factors, is the loss of ultraviolet radiation. This deficiency is believed to lead to a higher incidence of rickets, caries, and symptoms of other deficiency diseases. Statistics are cited to show the correlation between decreased sunlight with increased incidence of rickets, and pulmonary diseases.

The effect of polluted air on the respiratory system depends on physical characteristics, general health, conditions of the lungs, period during which polluted air was breathed, and on the degree of pollution. Smoke does not produce a disease peculiar to itself but rather must be regarded as a contributory factor in diseases having other causative factors. For this reason, the examination of the

effects of respiration of polluted air does not lend itself to isolated or statistical treatment. Moreover, much of the ill health for which smoke is probably most directly responsible is, in its early stages, not classified as disease, and is not included in any statistical records. The first and most common effect is the irritation by the polluting particles of the mucous lining of the entire respiratory tract. The reaction of this irritant is mucous discharge with resulting catarrh, sinusitis, coughing and hawking.

In a consideration of heavily-polluted air, as occurs with a dense fog, the situation is accelerated, and the respiratory system has to contend with abnormally severe difficulties. The acute irritation is due principally to the acid present in the fog. The consequences are reflected in the increased incidence of illness and mortality. In cities where smog may be particularly severe the rise in deaths in the wake of a fog is anticipated. A Glasgow newspaper automatically allows more space for the obituary notices whenever there is a fog. The most remarkable statistical evidence appears at end of the 19th century, when smoke pollution appeared to be at its peak. In 1873, there was a notorious smog over London, raising the death rate greatly. Another appeared in London in 1880. A five-day deadly smog appeared over Glasgow in 1909. It will be noted that the largest increase in the number of deaths occurs during the week following the heaviest fog. A fatal end to bronchitis does not usually occur until a week or more after the onset of the disease. Post mortems of victims of the Meuse Valley disaster revealed in every case acute irritation of the respiratory system with death from heart failure. An investigation of the air of the Meuse Valley revealed the presence of nearly 30 impurities, most of which could be injurious or poisonous. There is no doubt that deaths and illness were due to the principal contaminant, sulfurous and sulfuric acids.

The depressing effect of a smoky atmosphere is stressed. Everyone feels the stimulating effect of a fresh, sunny, summer morning, and few are the people who do not react the opposite to the depression of a smoke pall.

There is no certain relationship proven yet with smoke-laden air and cancer.

The effects on plants are equally, if not more, injurious. The effects can be more adequately measured quantitatively and under conditions not possible with man or animal.

The effects of polluted air are shown by a stunting of growth, loss of vigor, reduction in reproductive capacity, degradation of color, and death. There are four principal ways in which these injuries are caused: (1) Sunlight is an essential factor in plant life, and it is lost to the plants by the smog above and by the coating of soot on

the leaves; and (2) the coating of soot on the leaves tends to choke the stomata through which respiration is conducted. This explains the fact that conifers are the first to succumb because of the characteristic sunk stomata forming an efficient trap for soot; (3) the sulfur acids in the soot are held in contact with the leaf, and some are probably absorbed through the stomata, causing damage to the living cell and destroying chlorophyll; and (4) sulfuric acid becomes deposited in the soil, and the effects are then cumulative over the years.

Other sections of the volume are devoted to property damage and costs of air pollution. A separate section discusses the achievements in controlling air pollution.

321. Study and control of industrial atmospheric pollution nuisances. Stead, F. M. *Am. J. Pub. Health* 35: 491, 1945. (May)

Three types of nuisances are discussed: inert smokes and dusts, mucous membrane irritants, and malodorous substances. Sulfur dioxide is listed as the chief mucous membrane irritant. Others are chloride and phosgene and acid mists, such as sulfur trioxide and hydrogen chloride. Handling of the problem of air pollution requires two basic fundamentals; (1) public relations and (2) technical study of the problem. Attacking a legitimate nuisance complaint requires coverage of seven features, which include identity of causative agents, establishing sources, sampling air for concentration, study of factors affecting dilution, interpretation of results, and securing corrective measures.

321a. Public health aspects of atmospheric pollution. Clayton, G. D. *Ind. Hyg. Newsletter* 9: 10, 1949. (Dec.)

A general presentation of the subject of air pollution is given, with emphasis placed on the need for more knowledge of its effects and the methods for its control.

321b. Health implications of air pollution. Bloomfield, J. J. Presented 97th meeting of the American Society of Civil Engineers, New York, N. Y., Jan. 18, 1950.

The need for control of air pollution is especially urgent in view of the increasing industrial activity with its attendant pollution of the atmosphere. The health implications are discussed. A plea is made to engineers to play an active part in this rapidly expanding field.

321c. Polluted air. Bloomfield, J. J. Presented at the Women's City Club of New York, N. Y., Jan. 5, 1950.

A general discussion is presented of the problem as it relates to health. The need for more research work in the field is stressed.

The speaker emphasized the importance of public opinion in any campaign to control air pollution.

321d. Recent Advances in Public Health. Burn, J. L. Churchill, London, 1947.

Chapter 27 of this book refers to air pollution. It gives a general review of the subject with a majority of emphasis being placed on control.

321e. Air pollution control: a public health responsibility. Abrams, H. K. California's Health, 7: (1): 1, 1949. (July)

A general review of the effects on health is presented. The history of the subject is presented. The present status of the administrative problems concerned is discussed.

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